671

THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SEPTEMBER 1913

35 CENTS A COPY $3 A YEAR

ANNUAL MEETING: DECEMBER 2–5;

MONTHLY MEETINGS: NEW YORK, OCTOBER 14

APPLICATIONS MUST BE FILED BY SEPTEMBER 25

The season of the Society's greatest activity is about to begin, and this year a program has been planned that will be of great value and interest.

Those who are desirous of participating in the privileges which the Society offers should file their applications not later than September 25 for the following reasons:

a To participate as a member at the Annual Meeting in December.

b To be included in the Annual Year Book of the Society.

c To secure the published proceedings of the meetings during 1913.

d To participate in the frequent meetings held in the principal cities of the country, thereby increasing one's acquaintanceship, professional knowledge, etc.

Applications received after September 25 cannot be acted upon until after the Annual Meeting and will not be included in the 1914 issue of the Year Book.

Applications and information regarding n mbership may be obtained from the Secretary or from any of the undersigned.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

H. V. O. Coes	R. M. Dixon	E. B. Katte
F. H. Colvin	W. R. Dunn	R. B. Sheridan
J. V. V. Colwell	J. P. Ilsley	H. Struckmann

Chairmen of Sub-Committees

Boston, A. L. Williston	*New York,* J. A. Kinkead
Buffalo, W. H. Carrier	*Philadelphia,* T. C. McBride
Chicago, Fay Woodmansee	*St. Louis,* John Hunter
Cincinnati, J. T. Faig	*St. Paul,* Max Toltz
Cleveland, R. B. Sheridan	*San Francisco,* Thos. Morrin
Michigan, H. W. Alden	*Seattle,* R. M. Dyer

Troy, A. E. Cluett

SEPTEMBER 1913 VOL. 35 No. 9

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

CONTENTS

THE JOURNAL is published monthly by The American Society of Mechanical Engineers.
Price, 25 cents a copy, or $2 a year, to members and affiliates of the Society; 35 cents a copy or $3 a year to all others. Postage to Canada, 50 cents additional; to foreign countries, $1 additional.
Entered as second-class matter January 4, 1912 at the Postoffice, New York, N. Y., under the act of March 3, 1879.

COMING MEETINGS OF THE SOCIETY

October 10 (Probable Date), *Worcester, Mass.*, Worcester Polytechnic Institute. For details, see page 5.

October 14, *New York City*, 29 West 39th Street. Paper: Stability in Aeronautics, A. A. Merrill. For further details, see page 5.

November 19, *New Haven*, Mason Laboratory, Sheffield Scientific School. Subjects: Industrial Coöperative Research, and miscellaneous papers.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 SEPTEMBER 1913 NUMBER 9

During the summer months when no meetings are held and committee members are scattered, signs of activity at the Society's headquarters are naturally less marked than at the other and "busy" seasons. During the past summer, however, this has been true only to the extent that there have been fewer wheels of the Society's mechanism in motion. Such as have been kept in operation by committees able to undertake work in the vacation season have run smoothly and well and much has been accomplished.

Of the greatest importance to the welfare of the Society itself is the record of the Increase of Membership Committee, which last June succeeded in raising the membership to more than five thousand. There were 523 members added as a result of the ballot at the Spring Meeting, and since that time 387 applications have been received. The Society is increasing at the rate of one thousand members a year and if this should continue, as it is believed that it will, the coming season will end with a membership of six thousand.

A great deal of work has been accomplished by the committees on Power Tests and on Standard Specifications for the Construction of Steam Boilers, both of which are at work upon voluminous reports. The former committee is revising its preliminary report, as submitted at the last Annual Meeting, and the latter now has the copy for its forthcoming report in completed form in the hands of all its members, for their final

consideration before submitting it to the membership at large. In many respects these two reports are the most important ever issued by the Society. They ought to do much to standardize practice, and improve the efficiency and enhance the safety of power plant apparatus.

The Committee on Flanges and Flanged Fittings has been in conference with manufacturers of valves and fittings with a view to finding some ground on which manufacturers who have large commercial interests and a great deal of money tied up in patterns and castings can come together with a committee desiring to attain a standard to insure the greatest possible safety through a consistent proportioning of the various sizes of flanges and fittings. The situation in this regard was fully outlined in The Journal for August 1912. The changes from previous practice recommended by the committee referred mainly to heavy work and to sizes above 9 inches, where the main considerations are those of safety, and no expense should be considered too great to secure immunity from accident. Their recommendations were such as to secure a reasonable factor of safety throughout the whole range of sizes and a uniformity of dimensions providing for interchangeability of fittings.

Manufacturers at that time were beginning to supply material according to the 1912 U. S. Standard of Flanges and Flanged Fittings recommended jointly by the committee of this Society and that of the National Association of Master Steam and Hot Water Fitters, but a number of them announced that an extra charge would be made where a compliance with the standard necessitated a material change in the existing patterns.

As a result of the conferences our committee has been holding, a tentative schedule has been agreed upon which only awaits formal acceptance by the manufacturers and by the Society.

The new standard fully covers all considerations of safety, but it has not been found expedient to maintain the feature of interchangeability.

Another important undertaking which has been pushed rapidly is the preparation of the Society History, which it is expected will be completed during the present year. Dr. Hutton, secretary of the committee on Society History, is giving this his personal attention and devoting much time to its preparation.

Plans have further been in process by various committees

in charge of local meetings. Definite arrangements are already made for meetings in New York, New Haven, Conn., and Worcester, Mass., the latter being a development resulting from the very successful meetings that have been held in Boston.

NEW YORK MEETING FOR OCTOBER

In New York the opening meeting is set for the evening of Tuesday, October 14, in the Engineering Societies' Building, when Albert A. Merrill of Boston will present a paper on Stability in Aeronautics. Mr. Merrill is the founder of the Boston Aeronautical Society and a lecturer at the Massachusetts Institute of Technology upon the subject of aeronautics.

The question of stability is one of the most important to be studied in aviation. As at present designed the flying machine has no inherent stability, and Mr. Merrill has analyzed the forces involved in order to determine if by a change in design it is possible to increase the safety of the flying machine. He hopes to arouse among engineers a greater interest in aeronautics so that through their efforts it may be put upon a more scientific foundation in this country. Although aviation had its start in America through the work of Langley, Chanute and the Wright Brothers, we are now far behind France in so far as real scientific progress is concerned. The advance there is due to the excellent work accomplished in aeronautical laboratories, notably the Eiffel Laboratory, and there is urgent need of similar opportunities in this country for the study of the science of aeronautics.

INTERESTING MEETING TO BE HELD IN WORCESTER

A new departure is planned in the way of group meetings this fall by the members in the Boston district. It is expected that meetings will be held in other cities in that section, besides Boston, through the coöperation of the Boston members with those residing in the cities selected for meetings. The first of these will be held in Worcester about October 10. The matter is in charge of a special committee of Worcester members, Prof. W. W. Bird, chairman, and it is expected that a considerable number of the Boston members will take advantage of the facilities provided for their attendance. According to the tentative arrangements, a special train will leave Boston about noon, and the party will be conveyed by automobiles to the Worcester

Polytechnic Institute where luncheon will be served. At the afternoon session Prof. David L. Gallup will present a paper on Experiments with Aeroplane Propellers at the Worcester Polytechnic Institute, and there will be an inspection of the shops and laboratories. Those attending the meeting will then be taken in automobiles to the hydraulic testing plant, where there will be propeller tests, and to the administration building of the Norton Company where a paper on Modern Abrasives, their Manufacture and Use, by Aldus C. Higgins, George Jeppson and Charles H. Norton, will be presented. An inspection of the plant and works will follow, and the visitors will be taken by automobiles in small groups to inspect the various industrial plants in Worcester, comprising the steel works, car works, electric light plant, envelope works, loom works, etc. Dinner will be served at the New Bancroft Hotel and the party will return to Boston by special train, arriving about half past ten.

NEW HAVEN MEETING

The quarterly meeting of the New Haven members is announced for November 19, with afternoon and evening sessions, and will, as usual, be held in the Mason Laboratory of the Sheffield Scientific School. One session is to be devoted to the subject of Coöperative Industrial Research, and the other to general papers on a variety of topics.

ORGANIZATION FOR MEETINGS AT ATLANTA, GA.

Atlanta, Georgia, is the tenth city to organize local meetings of the Society. The movement began last June when an organization was effected of the local members of The American Society of Mechanical Engineers in Atlanta and vicinity, with Mr. Park A. Dallis as secretary. This was part of a general movement to bring about coöperation between the various engineering and architectural associations of the city. Besides the membership of The American Society of Mechanical Engineers there are branches of five national societies, the American Institute of Architects, the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Chemical Society, and the Engineering Association of the South.

It was felt that it would be highly desirable to bring about an affiliation of these interests such as has been done in several other cities to the benefit of engineers individually and of the profession as a whole.

The first step towards this affiliation was an old-fashioned Georgia barbecue held on July 12, attended by fifty-seven members of these various professional bodies, which was in reality an organization meeting. Allen M. Schoen, president of the local section of the American Institute of Electrical Engineers, called the meeting to order and briefly outlined its object and the means employed to bring this about. He called upon James Nisbet Hazelhurst, chairman of the executive committee of the local section of the American Society of Civil Engineers, who spoke of the movement and its advantages, and made a special plea for a wider participation of the technical man in public affairs.

The meeting was also addressed by L. J. Hill, Jr., president of the Atlanta section of the Engineering Association of the South, on the advantages of affiliation by the different technical organizations; by Hal Hentz, representing the American Institute of Architects, on the needs of professional advice in civic matters, such as parks and buildings; by J. S. Brogden of the Georgia section of the American Chemical Society, who spoke of the part of the chemical engineers in such an affiliation; and by Park A. Dallis, Mem.Am.Soc.M.E., on the needs of such an organization. Similar remarks were made by Capt. R. M. Clayton, chief of construction of the City of Atlanta, A. C. Bruce, a prominent architect, V. H. Kriegshaber of the Chamber of Commerce, F. H. Granger, a member of the Franklin Institute and also of the American Institute of Mining Engineers, B. M. Hall, a member of the American Society of Civil Engineers and of the American Institute of Mining Engineers, Prof. G. N. Mitcham of Auburn Polytechnic and also of the Alabama state highway commission, Prof. H. P. Wood of the Georgia School of Technology, Paul Norcross, and others.

As a result of this gathering, an executive committee was chosen to formulate a plan for permanent organization. An executive committee of the Society in Atlanta has also been nominated and will be submitted to the Council at its next meeting for confirmation, thus completing the organization and extending the influence of the Society to this important industrial and

railway center of the South. The local membership is greatly interested in the movement and is disposed to enter into the spirit of the work for the increase of membership which is now going forward so rapidly and which is adding so many prominent names to the roll of members throughout the country at the present time.

PROPOSED AMENDMENTS TO THE CONSTITUTION

The following amendments to the Constitution are to be presented at the Annual Meeting of the Society in New York in December:

C-9 A Member shall be an Engineer or Teacher of Applied Science of thirty-two years of age, or over, and shall have been in the active practice of his profession for at least ten years and in responsible charge of important work for five years, and shall be qualified to design as well as to direct engineering work. Fulfilling the duties of a Professor of Engineering who is in charge of a department in a college or school of accepted standing shall be taken as an equivalent to an equal number of years of active practice. Graduation from a school of engineering of recognized standing shall be considered as equivalent to two years of active practice.

C-11 An Associate-Member shall be a professional engineer not less than twenty-seven years of age, who shall have been in the active practice of his profession for at least six years, and who shall have had responsible charge of work as principal or assistant for at least one year. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice.

GIFT TO PROF. MATSCHOSS

A pleasing aftermath of the many satisfactions experienced during the trip through Germany was the presentation of a beautiful repeater watch by the members of the party to Prof. Conrad Matschoss, in recognition of his services during the trip and as an indication of personal appreciation.

When the trip was projected Prof. Matschoss came to America to consult with the officials of the Society about arrangements, and also visited the various cities in Germany to perfect arrangements, and from the time that the steamer touched at Plymouth until the ending of the trip at Munich was with the party constantly as its guide and helper. He was assigned by the Verein deutscher Ingenieure to attend to the many details of management connected with the great undertaking, and the fact that his duties were well performed and the trip made an unqualified suc-

cess afforded him the greatest satisfaction and was, from his standpoint, ample repayment for his devoted services.

As the trip advanced, however, there was an ever-increasing feeling of friendship and appreciation on the part of his American friends which led to a spontaneous movement for some expression of gratitude to Prof. Matschoss, resulting in the raising of a fund and the purchasing of the watch.

The gift is from the famous firm of Vacheron & Constantin at Geneva and was personally selected by Worcester R. Warner, who was in Switzerland immediately after the trip. It is engraved with the words: "Presented to Professor Conrad Matschoss as a token of appreciation and esteem by members of The American Society of Mechanical Engineers visiting Germany in 1913." The watch is a minute repeater, and was sent together with a chain of gold and platinum links, which as Mr. Warner expressed it to Prof. Matschoss, represents the welding of German and American sympathies and interests through his zealous efforts. He voiced also the wish that the watch might repeat its message to Prof. Matschoss with every ringing of its bells. The gift came evidently as a great surprise to Prof. Matschoss, who had written feelingly of his happy remembrances of the wonderful trip.

APPLICATIONS FOR MEMBERSHIP

The Membership Committee have received applications from the following candidates. Any member objecting to the election of any of these candidates should inform the Secretary before October 15, 1913:

Allison, Daniel K., Cincinnati, Ohio
Andrews, David, Newton Center, Mass.
Baker, Orth K., Tremp, Lerida, Spain
Baron, Leopold, Newark, N. J.
Bosworth, Wilbur McK., Pittsburg, Kan.
Bowser, Howard A., Buenos Aires, S. A.
Brice, Andrew F., New York, N. Y.
Bryen, George J., Duquesne, Pa.
Bullard, John E., Pt. Washington, N. Y.
Burt, Austin, Waterloo, Iowa
Case, Lynn B., Hudson Falls, N. Y.
Childs, John N., Salt Lake City, Utah
Conroy, Ramon A., Brooklyn, N. Y.
Coulter, James, Bridgeport, Conn.
Cowell, William A., Anderson, Ind.
Crane, Arthur M., New York, N. Y.
Dalas, Frank L., Long Beach, Cal.
Davis, George H., New Orleans, La.
Davis, James H., Brooklyn, N. Y.
Dighe, Shankerrao M., Baroda, India
Dowd, Bernard J., Hartford, Conn.
Du Vivier, Ernest H., New York, N. Y.
Estabrook, Harry M., Dayton, Ohio
Elster, Gurdon G., Montreal, Canada
Eveland, Samuel S., Philadelphia, Pa.
Farr, Arthur V., Maplewood, N. J.
Faulkner, David S., New York, N. Y.
Feiss, Richard A., Cleveland, Ohio
Gammeter, Harry C., Cleveland, Ohio
Gannon, Thomas J., Brooklyn, N. Y.
Gardiner, Walter B., Erie, Pa.
Gay, Frederick W., San Francisco, Cal.
Gibson, Charles D., Chicago, Ill.
Green, Frederick W., Stamps, Ark.
Grover, Charles L., Bethlehem, Pa.
Hall, Arthur G., Cincinnati, Ohio

Hanks, Henry M., Narberth, Pa.
Harrold, Frederick F., Munhall, Pa.
Hopkinson, Joseph, Dayton, Ohio
Heinze, John O., Detroit, Mich.
Henn, Oliver L., Cleveland, Ohio
Huestis, Bronson, Brooklyn, N. Y.
Israel, Albert H., New York, N. Y.
Johnson, Allen E., Westmount, Canada
Keller, J. M., Cleveland, Ohio
Kellogg, Morris W., New York, N. Y.
Kennedy, William P., New York, N. Y.
Knight, William, E. Orange, N. J.
Landis, Mark H., Waynesboro, Pa.
Leeson, Charles G., Oroville, Cal.
Lindemann, Walter C., Milwaukee, Wis.
Lord, Caleb W., Philadelphia, Pa.
Lord, Harold S., Athol, Mass.
McClintock, Allan P., Bayonne, N. J.
MacAllister, Robert N., Chicago, Ill.
Mardaga, Louis, Baltimore, Md.
Marx, Henry J., Poughkeepsie, N. Y.
Matschoss, Conrad, Berlin, Germany
Misch, Arthur A., Cleveland, Ohio
Morgana, Charles, Jr., Detroit, Mich.
Nicolai, Charles A., Orange, N. J.
Pfeiffer, Charles G., Philadelphia, Pa.
Pohle, Richard F., Lynn, Mass.
Purchas, Arthur W., Oilfields, Cal.
Richardson, Ammi C., Holyoke, Mass.
Riggs, F. Stanley, Akron, Ohio
Roberts, Richard F., New York, N. Y.
Robison, Charles J., Canton, Ohio
Schroeder, Ernst O., Ann Arbor, Mich.
Sly, Frederick S., Chicago, Ill.
Smith, Donald F., Detroit, Mich.
Smith, Edric B., New York, N. Y.
Stults, William R., Orange, Mass.
Tait, Edward H., Easton, Pa.
Tinsley, George W., Tremp, Lerida, Spain
Tonkin, Ellsworth, Canton, Ohio
von der Werff, J. N., Toronto, Canada
Warner, Raymond C., Pittsburgh, Pa.
Wein, Charles V., So. Bethlehem, Pa.
Wheelhouse, Sidney H., Salem, Ohio
Wilson, Hugh M., Hartsdale, N. Y.

PROMOTION FROM ASSOCIATE

Clarke, Charles W. E., Boston, Mass.
Johnson, Bradley S., Chicago, Ill.

PROMOTION FROM JUNIOR

Coburn, Frederick G., Philadelphia, Pa.
Forté, Harry P., Canajoharie, N. Y.
Gates, Thayer P., Saylesville, R. I.
Posselt, Ejnar, Denver, Colo.
Wegg, David S., Boise, Idaho
Wentworth, R. A., Philadelphia, Pa.

SUMMARY

New applications	80
Promotion from Associate	2
Promotion from Junior	6
	88

THIRD INTERNATIONAL CONGRESS OF REFRIGERATION

At the invitation of the President of the United States the Third International Congress of Refrigeration will be held in Washington and Chicago, September 15-24, inclusive.

The delegates from the foreign countries will be received and entertained in New York City during the week of September 8. An attractive program of entertainment and excursions to points of general and technical interest has been arranged to cover the entire week. During this time the headquarters of the Congress will be in the rooms of the Society.

The delegates will proceed to Washington on Sunday, September 14, and on the following day the formal opening session of the Congress will be held, with a reception by the President and addresses by a number of government officials.

On Tuesday, September 16, those in attendance will proceed to Chicago for a series of meetings to be held in the International Amphitheater, extending over a period of a week. The Congress will be divided into six sections for the consideration of technical and legislative matters of interest to the great industry of refrigeration. The first section of the Congress, devoted to liquid gases and units, is under the direction of William Kent, chairman, and Calvin W. Rice, secretary. Other members of the Society prominently identified with the Congress are: G. T. Voorhees, Assistant Secretary-General, D. S. Jacobus, J. W. Lieb, Jr., Charles E. Lucke, E. F. Miller, and S. W. Stratton.

A number of extended excursions have been arranged to San Francisco, Panama and other distant points in which the delegates will participate subsequent to the Congress.

Programs and full information regarding the Congress may be obtained from J. F. Nickerson, Secretary-General, 431 South Dearborn Street, Chicago, Ill.

MEETING ON IRON AND STEEL

A meeting of the American Institute of Mining Engineers under the auspices of the Iron and Steel Committee of the institute, will be held in New York on October 16 and 17. An informal dinner and smoker will be given on the evening of October 17 to which as well as to the professional sessions the membership of the Society is invited. Papers upon the following subjects will be presented:

Blast Furnace Gas Cleaning, W. A. Forbes

The Quality of Cast Iron as affected by Oxygen, Nitrogen and Other Elements, J. E. Johnson, Jr.

Oxygen in Steel, W. R. Shimer

New Design of Regenerators for Open-Hearth Furnaces, H. F. Miller, Jr.

Shock Tests of Cast Steel, J. H. Hall

Scoria Process, E. Stutz

Briquetting, Felix A. Vogel

Uses and Advantages of Briquettes in Blast-Furnace Practice, Felix A. Vogel

Discussion of the Existing Data as to the Position of Ae_3, H. M. Howe

Determination of the Position of Ae_3 in Carbon-Iron Alloys, H. M. Howe and A. G. Levy

Ae_3, the Equilibrium Temperature for A_1 in Carbon Steel, H. M. Howe

The Divorcing of the Eutectoid in Meteorites, H. M. Howe

Thermal and Microscopical Examination of Professor Howe's Standard Commercial Steels, G. K. Burgess, J. J. Crowe and H. S. Rawdon

Influence of Alloying Elements on the Carburization of Steel, R. R. Abbott
Some Phases of the Practical Treatment of Tool Steel, J. V. Emmons
The Influence of Copper upon the Physical Properties of Steel, G. H. Clevenger and B. Ray
Resistance of Steels to Wear in Relation to their Hardness and Tensile Properties, J. L. Norris
Paper comparing the Records of Crucible Furnaces for Steel Making, J. H. Hall

PITOT TUBES FOR GAS MEASUREMENT

By W. C. Rowse

ABSTRACT OF PAPER

A series of experiments has been made by the author at the laboratories of the University of Wisconsin to obtain information concerning the reliability of the pitot tube as a means of measuring gases and to determine the accuracy of various forms of the instrument which are in common use. All tubes were compared with a Thomas electric gas meter which was taken as a standard of measurement. Since any variation in results would be due to a wrong method of obtaining the static pressure, simultaneous readings were taken of velocity heads as shown by the pitot tube using the pitot static pressure and by the pitot dynamic tube and a piezometer. The pressure as obtained by the piezometer would not be affected by the form of tube used.

The results, which are treated in Par. 42 to 46, may be discussed briefly as follows:

a The pitot tube is a reliable means of measuring gases when the static pressure is obtained in a correct manner and when all readings are taken with a sufficient degree of refinement.

b The piezometer is the most reliable means of obtaining the static pressure.

c Of the various forms of static openings in the pitot tube itself, very small holes in a perfectly smooth surface give the most accurate results.

d Slots give erroneous static pressures and beveled-end tubes for obtaining static pressures are not reliable.

e The German Stauscheibe is a reliable means of measuring gases.

PITOT TUBES FOR GAS MEASUREMENT

By W. C. Rowse, New York

Junior Member of the Society

The measurement of gases is receiving increased attention in this country and in Europe. The vast quantities of natural and manufactured gas consumed for power, lighting and heating must be measured with precision not only because of their value but because modern business methods demand accuracy. Blowers and ventilating fans are usually sold under a guarantee that they will deliver a certain volume of air or gas under given conditions, but often the two different methods employed by the seller and the purchaser in measurement disagree and neither one has indisputable evidence that his method is correct. Other instances might be cited to show the need of more knowledge concerning the accuracy of various methods of measuring gases.

2 The pitot tube as a means of measuring gases has been described by many writers and investigators.[1] It has the advantage of being correct in principle, inexpensive, portable, and is in general easily applied. But the accuracy of the different forms of pitot tubes has long been questioned, the maker of each form supposing that his tube is correct, while as a matter of fact no two forms of tube agree. There has long been need for a careful, scientific study of the pitot tube for the measurement of gas and a fair comparison of the different forms in common use.

3 The purpose of the experiments which were made in the

[1] D. W. Taylor, Experiments with Ventilating Fans and Pipes. Society of Naval Architects and Marine Engineers, November 1905; Frank H. Kneeland, Trans. Am. Soc. M. E., vol. 33, p. 1137; G. F. Gebhardt, Journal Am. Soc. M. E., November 1909; R. Burnham, Engineering News, December 21, 1905; Forrest M. Towl, Columbia University Lectures, 1911; Chas. H. Treat, Trans. Am. Soc. M. E., vol. 34, p. 1019; Thos. R. Weymouth, Trans. Am. Soc. M. E., vol. 34, p. 1094.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

laboratories of the University of Wisconsin and which form the subject matter of this paper may be stated briefly as follows:

a To investigate the reliability of the pitot tube as a means of measuring gases.

b To ascertain which forms of the pitot tube now in common use give correct and which incorrect results in the measurement of gases.

4 It was planned to force air through a pipe in which the pitot tube to be tested was inserted, together with a standard

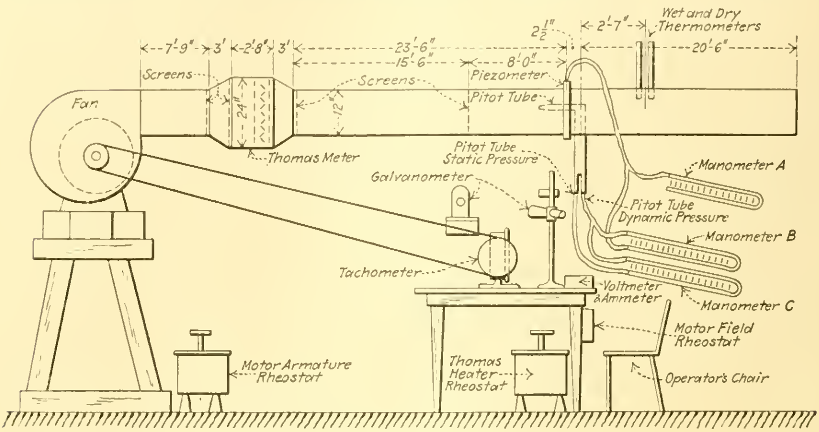


Fig. 1 Sketch of Apparatus

gas meter, known to be correct. This plan as a whole presented no difficulties except the selection of a standard gas meter concerning whose accuracy there could be no question.

5 The only fundamentally correct means of measuring directly the volume of a large quantity of flowing gas is the displacement or "holder" method. A holder of known dimensions drops a given distance, thus forcing a certain definite volume of gas through the discharge pipe, where it is again measured by the meter to be tested. The temperature, pressure and humidity of the gas both in the holder and at the apparatus to be tested must be known in order that both volumes may be reduced to the same conditions and thus a fair comparison may be made. It is a very difficult matter to obtain fair average readings of these quantities, especially of the temperature, because of the influence of the water in the holder, of the weather conditions outside, and of the large volume of gas in the holder. There

are certain periods in the spring and autumn when the temperature remains practically constant day and night for several days, and this is the only time when holder tests can be made with any approach to accuracy.

6 These considerations, as well as the fact that the holder is clumsy, intermittent in action and altogether unsuited for laboratory experiments, made its use as a standard of measurement out of the question.

7 The Thomas electric gas meter [1] which has been developed

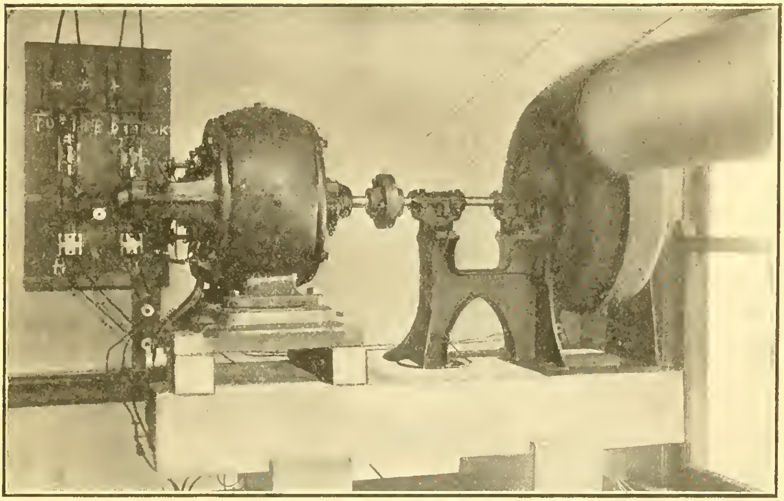


Fig. 2 View of Fan and Motor

during the last few years and which is described in detail in a later portion of this paper, was used as the standard gas meter in the experiments with pitot tubes for the following reasons:

a It measures weight of gas, and avoids the difficulties inherent in volumetric measurements.

b Its measurement of gas depends directly upon the specific heat of a gas. The specific heat varies but slightly with wide changes in temperature, pressure and humidity.

[1] Carl C. Thomas: Electric Gas Meter, The Journal, Am. Soc. M. E., December 1909; Measurement of Gas, Journal of the Franklin Institute, November 1911; Some Recent Developments in Gas Measuring Apparatus Proc., Am. Gas Inst., vol. 7, 1912.

c Its accuracy is limited only by the exactness of electrical measurements; such measurements can be made by engineers with a very great degree of refinement with well-known highly developed instruments.

d It has been thoroughly tested by experiments under the most varied conditions in this country and abroad; some of the results of tests are presented in Appendix No. 1, and in every instance it was proven that the meter was correct not only in theory but also in the actual measurement of gases.

e Its operation is very simple, the readings are few and can be obtained with the greatest accuracy, while it requires almost no attention itself when in use.

DESCRIPTION OF THE APPARATUS

8 The apparatus used in the experiments on pitot tubes is shown diagrammatically in Fig. 1 and by photographs in Figs. 2, 3 and 4.

9 A No. 2½ Sirocco fan driven by a 7½-h. p. direct-current shunt-wound motor forces air through the Thomas meter into a galvanized iron pipe 12 in. in diameter in which the pitot tube to be tested is inserted.

10 Variable resistances were placed in series with both the field and the armature of the motor, thus making possible a wide variation in speed. A stationary tachometer belted to the fan was so located that it could be observed at all times by the experimenter at the pitot tube. The field rheostat was brought within reach of the operator so that the fan could be maintained at any desired constant speed during a test.

11 Screens were inserted at the points shown in Fig. 1 in order to break up eddies and whirls and to have the air flow as nearly parallel as possible at the point where the pitot tube readings were taken. All joints between the Thomas meter and the pitot tube were made thoroughly air tight to prevent leakage. The barrel of the Thomas meter was lagged by three thicknesses of heavy blanket in order to prevent any possibility of error due to radiation to or from the meter casing.

12 The experimenter was stationed directly under the pitot tube and all readings were taken at this point. A mercury barometer, hung on the adjacent wall, gave the atmospheric pressure, and a manometer inclined at a 10 to 1 slope made it possible to

determine accurately the static pressure in the pipe above atmosphere. The dry-bulb thermometer indicated the temperature of the air flowing in the pipe and together with the wet-bulb thermometer gave readings from which the humidity could be determined.

THE THOMAS ELECTRIC METER

13 The Thomas electric meter is based on the principle of

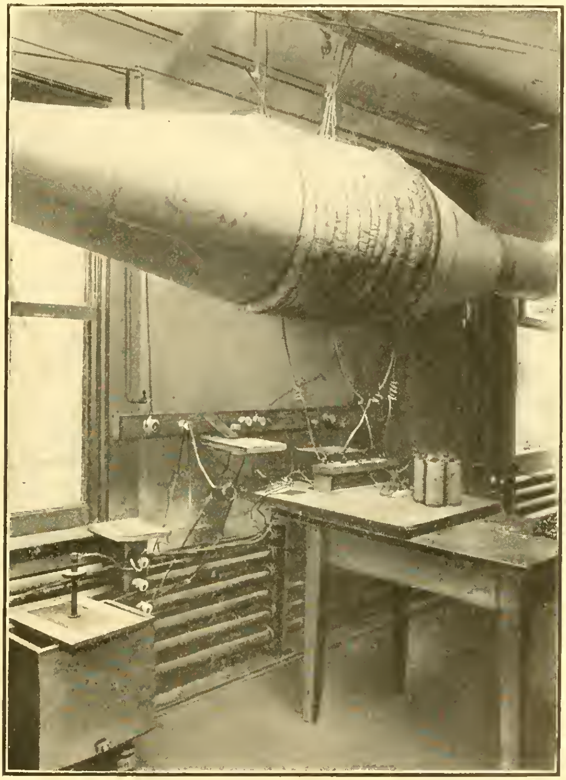


FIG. 3 VIEW OF THOMAS METER

heating the gas through a known range of temperature and measuring the energy required to cause this change in temperature: this measured heat is proportional to the weight of gas flowing. Electric energy is used as the source of heat as it can be accurately measured and easily controlled. The temperature range is determined by the use of electrical resistance thermometers.

If E is the amount of energy in watts supplied to the heating coils to raise the temperature of W lb. of gas per minute through t deg. fahr., and if s is the specific heat at constant pressure of 1 lb. of gas, then

$$W = \frac{0.05686E}{ts}$$

14 The manually controlled Thomas meter used in these experiments is shown diagrammatically in Fig. 5. An electric

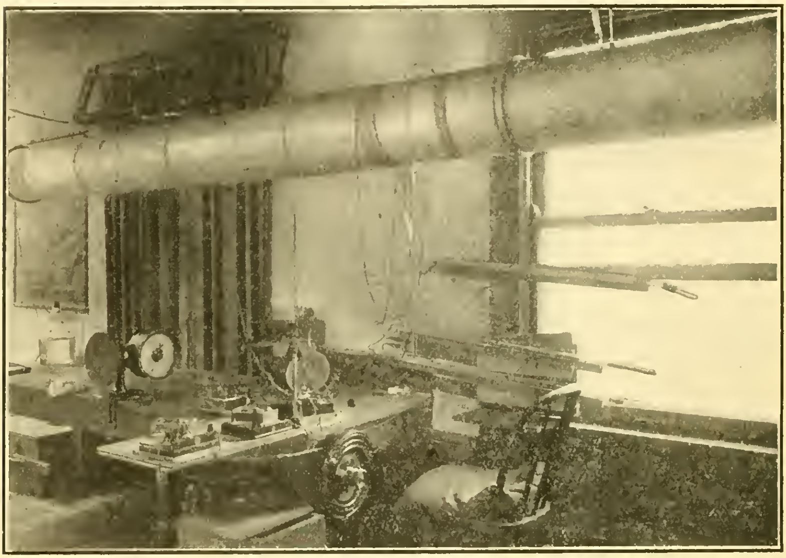


FIG. 4 VIEW TAKEN AT OBSERVER'S STATION

heater is placed within a casing between two electric resistance thermometers T_1 and T_2. The heater consists of bare resistance wire mounted on a fiber frame and evenly distributed over the section of the casing. A water rheostat is placed in the heater circuit for regulating the direct-current supplied. The energy is measured by an ammeter and a voltmeter, both accurately calibrated in the standards laboratory of the electrical department of the University of Wisconsin after each series of tests.

15 The thermometers consist of nickel resistance wire wound on insulated wooden spindles which are evenly distributed over the cross-section of the casing. These thermometers were calibrated simultaneously by the author by means of a special ap-

paratus at the plant of The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., where the commercial form of the Thomas electric meter is manufactured. The results of this calibration are given by the curves in Fig. 26, Appendix No. 2. This curve shows the ohms increase in resistance per degree rise in temperature for any ordinary temperature. These two thermometers were arranged to form two arms of a Wheatstone bridge.

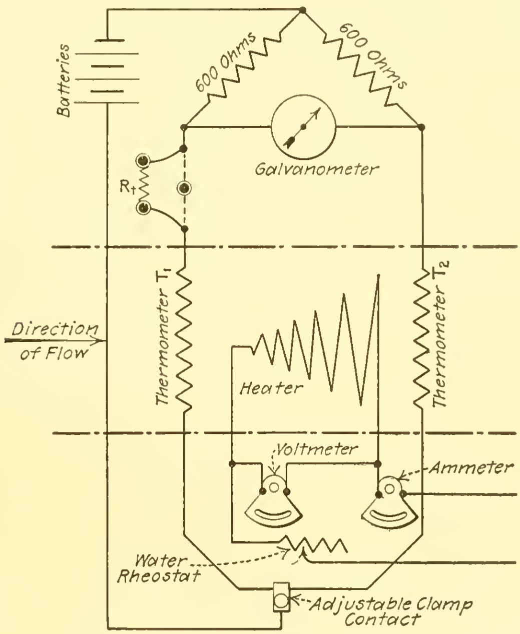


Fig. 5 Diagram of Thomas Electric Meter

of which the other two arms were fixed resistance coils (600 ohms each), made of wire having a zero temperature coefficient. A galvanometer is connected across the Wheatstone bridge thus formed and an adjustable clamp contact is provided to balance the bridge when no heat is passing through the heater. A small resistance R_t, also with zero temperature coefficient, is arranged so that it can be placed in or out of series with the entrance thermometer. The resistance R_t used in these experiments was 2.7998 ohms at all temperatures.

16 The operation of the meter is as follows: With gas flow-

ing steadily through the meter but with no energy in the heater, and with R_t out of circuit, the Wheatstone bridge is balanced by means of the adjustable clamp contact. Then the resistance R_t is put in circuit and sufficient electrical energy is supplied to the heater to bring the galvanometer to a balance again. This balanced state can be attained only by bringing the exit gas to such a temperature above that of the entering gas that the resistance of thermometer T_2 has increased 2.7998 ohms above the resistance of the thermometer T_1. The required increase in temperature of the gas varies slightly with the average gas temperature and may be found from the curve in Fig. 26, Appendix No. 2. The electrical measuring instruments in the heater circuit indicate the energy input which has been required to raise the temperature of the gas through the known range. The pounds of gas flowing per minute can then be found by the equation given in the preceding description.

17 The experimental work to be described was done after about two years' experience with the Thomas meter as a piece of regular laboratory apparatus, during which time its accuracy had been fully established.

THE PITOT TUBES

18 The pitot tube is a well-known measuring instrument and needs only a brief description. It consists essentially of two parts: a dynamic tube pointing upstream which converts the sum of the pressure energy and the velocity energy into a head which may be measured; and a means of determining the pressure head (or static pressure) alone. The difference between the dynamic head and the static pressure head is the velocity head h in the fundamental formula for the flow of fluids

$$v = \sqrt{2\ gh}$$

where

v = velocity in ft. per second

g = 32.2 ft. per second per second

h = mean velocity head in ft. of the fluid flowing

19 It has been satisfactorily proved and accepted that the dynamic tube gives the correct pressure if the tube points parallel to the current. But it is a very difficult matter to obtain the correct static pressure on account of secondary velocity effects. Therefore the study of the accuracy of the pitot tube resolves

itself into a study of the correct method of obtaining the static pressure at the given cross-section where the tube is inserted.

20 Each pitot tube tested had as a part of the tube a means of determining the static pressure, and readings of the velocity head were obtained by using this pitot tube static pressure. Simultaneous readings of the velocity head were obtained by using a piezometer ring for the static pressure together with the dynamic tube of the pitot tube under test. This is further illustrated by reference to Fig. 1. Manometer *B* gives the velocity head by using the piezometer static pressure, and manometer *C* gives the velocity head by using the pitot tube static pressure.

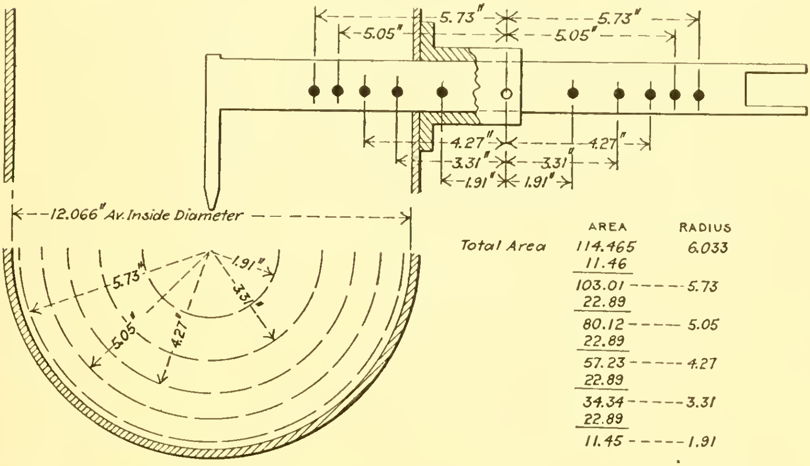


Fig. 6 Sketch showing positions at which Readings of Velocity Head were taken

In both cases the same dynamic tube pressure is used. This piezometer, even if it were possible to be in error, would always indicate the same pressure under the same conditions irrespective of the tube under test and thus it afforded an additional means of *comparison* independent of the Thomas meter.

21 The piezometer is shown in Fig. 1 and Fig. 7 and is simply an absolutely air-tight annular space about the pipe, connected with the interior of the pipe by six small holes 0.04 in. in diameter.

22 The velocity of a gas flowing through a pipe is much greater at the center than near the walls of the pipe.[1] In addi-

[1] Loeb, Journal American Society of Naval Engineers, 1912, p. 1115.

tion, it was apparent from the tests that the gas flows through the pipe with a wave or spiral motion even when many screens are inserted to straighten out the stream lines. Therefore, it was

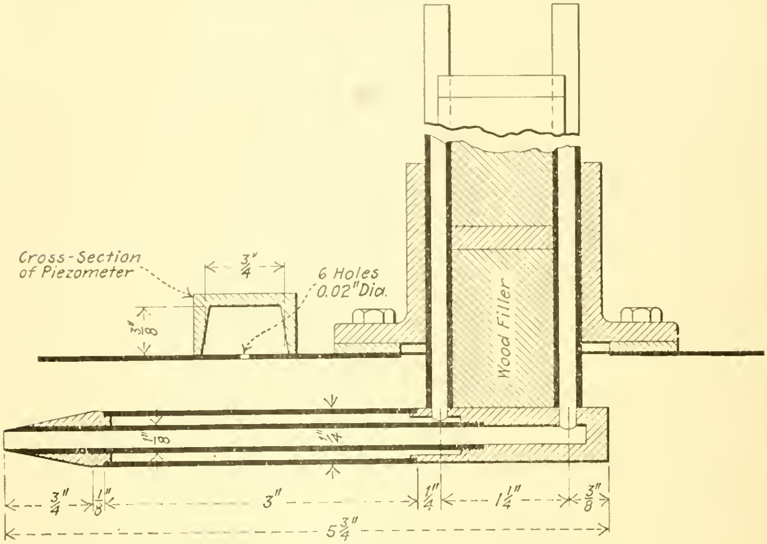


Fig. 7 Dimensioned Sketch of Pitot Tubes *A* to *H*

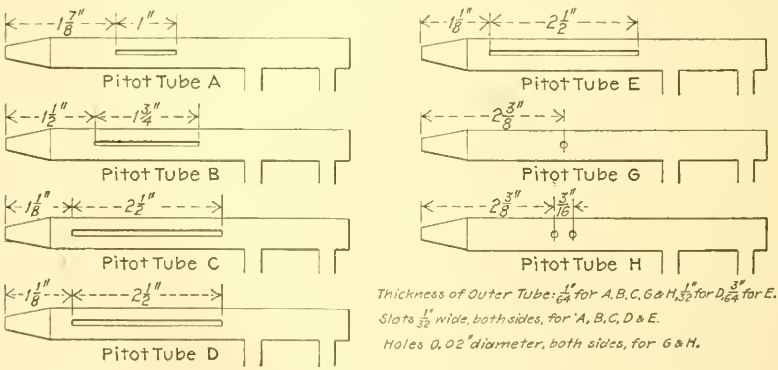


Fig. 8 Sketches of Pitot Tubes *A* to *H* showing Dimensions of Static Openings

necessary to take a large number of readings across two diameters of the pipe. The total area of the pipe was divided into five concentric annular areas and four readings of the velocity head were obtained in each test at the center of each annular area, thus giving 20 readings from which the mean velocity head

could be calculated. Since the velocity varies as the square root of the velocity head it was necessary to average the square roots of each of the 20 readings, and the square of this average represented the mean velocity head. The positions on the diameter at which the readings were taken are shown in Fig. 6.

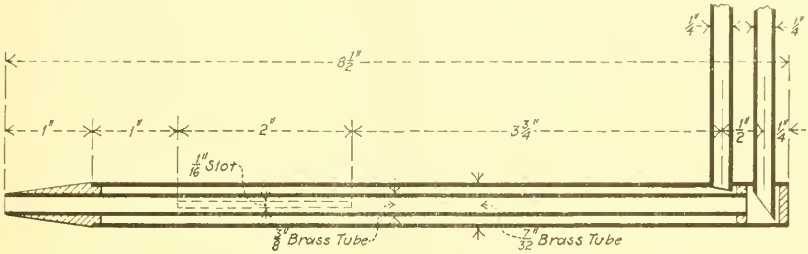


FIG. 9 DIMENSIONED SKETCH OF PITOT TUBE X

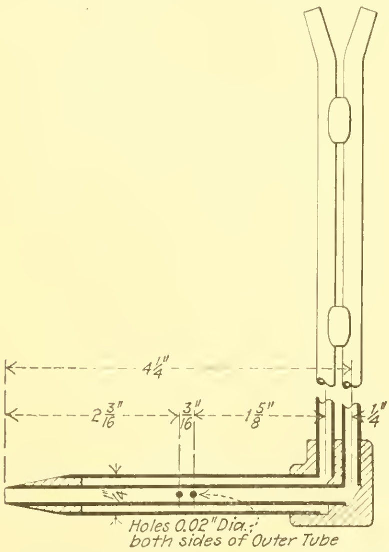


FIG. 10 DIMENSIONED SKETCH OF PITOT TUBE Y

Readings were also taken at the center of the pipe in order to determine if any definite relation existed between the mean velocity head and the velocity head at the center of the pipe.

22 The pitot tube under test was held in place by means of a brass bushing or holder which could be fastened by screws to brass facings soldered to the outside of the galvanized air

pipe. The facings were 90 deg. apart, thus permitting readings to be taken on both the horizontal and vertical diameters. Each pitot tube was first carefully centered in the pipe and a dowel hole bored in the shank corresponding to a hole in the holder. Ten other holes were bored in the shank at the proper distances either side of the center (see Fig. 6), so that by the use of a dowel pin the pitot tube could be quickly and accurately placed in its proper positions in the tube.

23 The pitot tubes tested in these experiments may be de-

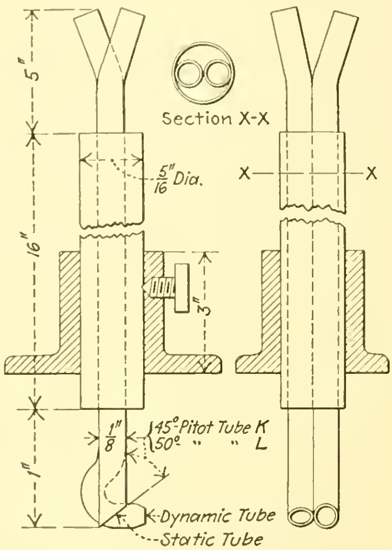


Fig. 11 Dimensioned Sketch of Pitot Tubes *K* and *L*

scribed briefly as follows: Tubes *A*, *B*, *C*, *D*, *E*, *G* and *H* are shown by sketches in Figs. 7 and 8. An experimental pitot tube was constructed as shown in Fig. 7 with a removable outer tube which contains the static opening. By inserting different outer tubes the seven pitot tubes shown in Fig. 8 were made. Tubes *A*, *B* and *C* are alike except for the length of the static slot. Tubes *D* and *E* are like tube *C* except for the thickness of the outer tube as shown in Fig. 8. Tubes *G* and *H* have small holes 0.02 in. in diameter for the static openings.

24 Tubes *X* and *Y* were loaned to the University of Wisconsin through the courtesy of Mr. F. R. Still of the American Blower Company. Tube *X*, Fig. 9, was made from a drawing

furnished by Captain D. W. Taylor,[1] U. S. N.; this form of tube is used as a standard for ventilation work by the United States Navy. Tube *Y*, Fig. 10, is the standard tube of the American Blower Company, and was developed by Mr. Chas. H. Treat, who has thoroughly tested the tube for accuracy.[2]

25 Tubes *K* and *L*, Fig. 11, were constructed from descriptions of the tubes developed by Prof. G. D. Gebhardt[3] of the Armour Institute of Technology. These were alike except that the static opening of the tube *K* was beveled to 45 deg., while in tube *L*, the static opening was flatter, being beveled to an angle of 50 deg. as shown in Fig. 11.

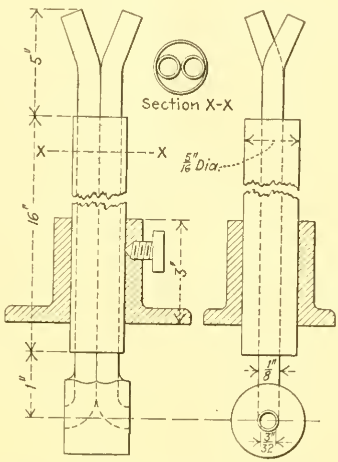


FIG. 12 DIMENSIONED SKETCH OF GERMAN STAUSCHEIBE

26 The "Stauscheibe,"[4] Fig. 12, has been widely used for several years in Germany and the experiments on this early form of pitot tube will be of interest for purposes of comparison.

GAGES FOR MEASURING THE VELOCITY HEADS

27 The velocity heads measured were very small quantities, ranging from 0.08 in. to 1.6 in. of gasolene, so that gages of

[1] Capt. D. W. Taylor; Soc. Naval Architects & Marine Engrs., Nov. 1905.

[2] Chas. H. Treat; Measurement of Air in Fan Work, Trans. Am. Soc. M. E., Vol. 34, p. 1019.

[3] Trans. Am. Soc. M. E., Vol. 31, p. 601.

[4] Reitschel; Versuche uber den Widerstand bei Bewegung der Luft in Rohrleitungen. Gesundheits Ingenieur, Festnummer July 1905. Marx; Uber die Messung von Luftgeschwindigkeiten. Gesundheits Ingenieur 1904.

unusual accuracy had to be used. From previous experience it was known that the inclined manometer when properly constructed and carefully calibrated would give readings which were correct within the required limits of error. Two gages were therefore constructed as shown by sketch in Fig. 13. The glass tubes were approximately 0.575 in. outside diameter and were selected with the greatest care from a large stock, special atten-

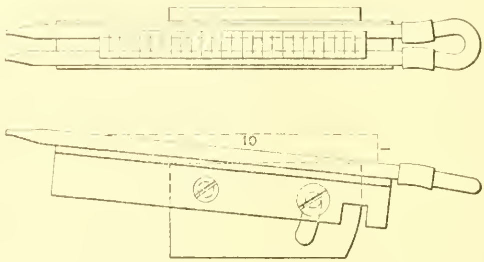


FIG. 13 SKETCH OF INCLINED MANOMETERS *A* AND *B*

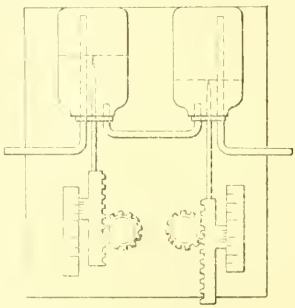


FIG. 14 DIFFERENTIAL HOOK GAGE USED AS A STANDARD

tion being given to straightness, uniformity of bore and freedom from flaws. These gages were placed at a ten to one slope by means of an accurate template and a spirit level which was correct to 0.002 in. in 10 in. They were calibrated before and after each series of runs by means of the differential hook gage and micrometer, shown in Fig. 14. A few such representative calibrations are given in the Table 1.

28 A sliding scale made it possible to read the velocity head directly. Gasolene was used as a manometer fluid because it automatically kept the inside of the glass tubes clean, had a very

definite meniscus and had almost no capillary attraction for the glass. Several preliminary tests were run to determine whether the vapor tension of the gasolene vapor affected the readings. The manometers were first made to check each other when both contained gasolene and then the same pressure was measured when one manometer was filled with gasolene and the other with kerosene. Identical pressure readings were obtained with kerosene as with gasolene. It, therefore, seemed evident that the

TABLE 1 SAMPLE CALIBRATIONS OF MANOMETERS *B* AND *C*

PRESSURES IN INCHES OF GASOLENE

Differential Hook Gage	Manometer *C*	Manometer *B*	Differential Hook Gage	Manometer *C*	Manometer *B*
1.872	1.863	1.857	1.530	1.531	1.513
1.657	1.658	1.654	1.382	1.387	1.375
1.465	1.461	1.451	1.216	1.214	1.215
1.285	1.278	1.274	1.051	1.053	1.045
1.071	1.076	1.071	0.948	0.956	0.949
0.877	0.878	0.877	0.836	0.837	0.830
0.768	0.773	0.770	0.727	0.735	0.730
0.665	0.669	0.667	0.503	0.508	0.502
0.560	0.570	0.568	0.397	0.400	0.397
0.462	0.468	0.460	0.286	0.290	0.284
0.368	0.369	0.367	0.224	0.225	0.220
0.175	0.170	0.168	0.103	0.109	0.105

Sp. Gr. Gasolene = 0.735 Sp. Gr. Gasolene = 0.736

vapor tension of either vapor in the manometer had no appreciable effect on the accuracy of the readings.

29 The large bore of the glass tubes (about ½ in. inside diameter) reduced any effect of capillary attraction to a negligible quantity and provided a reservoir of air which made the gages less sensitive to minor variations in the velocity head and therefore facilitated accurate reading.

DESCRIPTIONS OF THE EXPERIMENTS

30 The general plan of the experiments was to calibrate each pitot tube against the Thomas meter under approximately similar conditions. Two series of eight or nine tests each were made with each tube, one series being made with the end of the pipe open (full gate), which provided the condition of high velocity with low static pressure; and the other series being made with the opening in the end of the pipe restricted to one-half the pipe

area (half gate), thus providing the condition of low velocity and high static pressure. During each test the speed of the fan was kept constant for the length of time necessary to obtain all readings (20 to 30 minutes).

31 The procedure was as follows: The Thomas meter was "balanced" by causing air to flow through the pipe when there was no current flowing through the heater and the resistance R_t (Fig. 5) was out of circuit; and by moving the adjustable clamp contact until the galvanometer came to a balance. Several half days were consumed in checking and rechecking the first balance point, but ordinarily 30 minutes preceding and following a series of tests was sufficient to show that it had not changed. At frequent intervals a half day's run was made to check the original balance point. After the Thomas meter was once balanced it was found that it was not necessary to move the adjustable clamp contact again, showing that the electrical apparatus was not affected appreciably by a change in temperature from 60 deg. to 100 deg. fahr.

32 Manometers *B* and *C*, Fig. 1 and 13, were filled with gasolene of known specific gravity and carefully adjusted until their readings agreed on the average with the differential hook gage, Fig. 14. The pitot tube was tested for leaks, placed in position in the pipe and properly connected to the manometers by small rubber tubing, after which this rubber tubing was tested for air leaks.

33 When all was in readiness the fan was brought to the speed desired for the first test, the resistance R_t (Fig. 5) was placed in the thermometer circuit of the Thomas meter, the switch to the heater circuit was closed and the electrical energy to the heater regulated by the water rheostat until the galvanometer again came to a balance. Then keeping the speed constant and the galvanometer balanced, the pitot tube was placed successively at the proper points across the two diameters of the pipe and readings of the velocity head were obtained at each point. During the intervals when the manometers were coming to rest all necessary readings of pressure, temperature, revolutions per minute of fan, taken by a hand revolution counter, and volts and amperes in the heater circuit of the Thomas meter were obtained. The fact that the direct current used was furnished by a turbo-generator set having excellent voltage regulation and which supplied current for no other machines, contributed greatly

to the constancy of conditions and to the ease of obtaining accurate data.

34 When all data had been obtained for the first test the speed of the fan was increased until the tachometer needle pointed to the next determined speed, the current to the Thomas

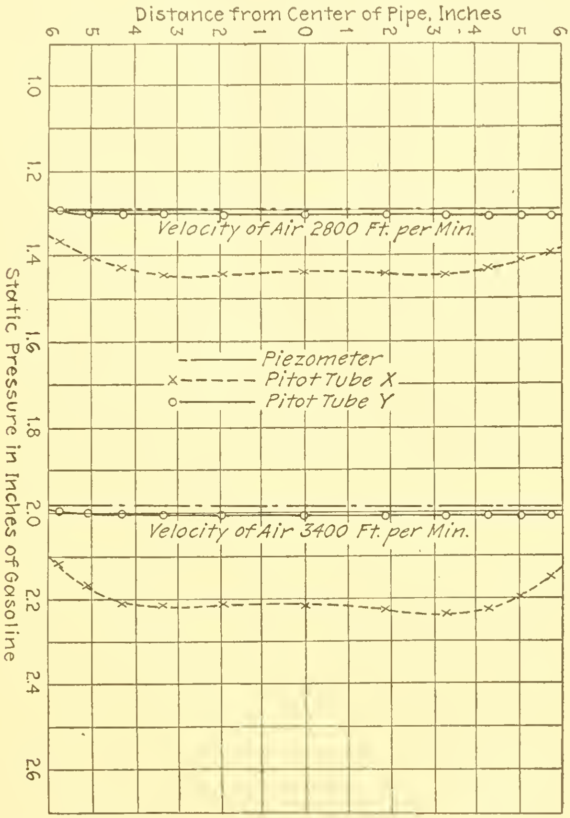


Fig. 15 Static Traverses of Pipe taken by Pitot Tubes X and Y under the Same Conditions of Velocity and Static Pressure

meter was regulated until the galvanometer balanced and then all readings were obtained as before.

35 At the end of a day's run the resistance R_t (Fig. 5) was cut out of circuit and the Thomas meter balanced with no current flowing through the heater, the manometers B and C were calibrated by means of the differential hook gage and the gasolene emptied out of the manometers to check its specific gravity.

LIMITS OF ACCURACY

36 The greatest possible error in the Thomas meter was the personal error of reading the volts and amperes to the heater and this error is estimated to be under 4/10 of 1 per cent. The thermometers used were carefully selected and calibrated by means of a standard thermometer from the Bureau of Standards. and were known to be accurate for the temperatures read during these experiments. The static and barometric pressures were readable to within 1/20 of 1 per cent.

37 From an inspection of the two calibrations given in Table

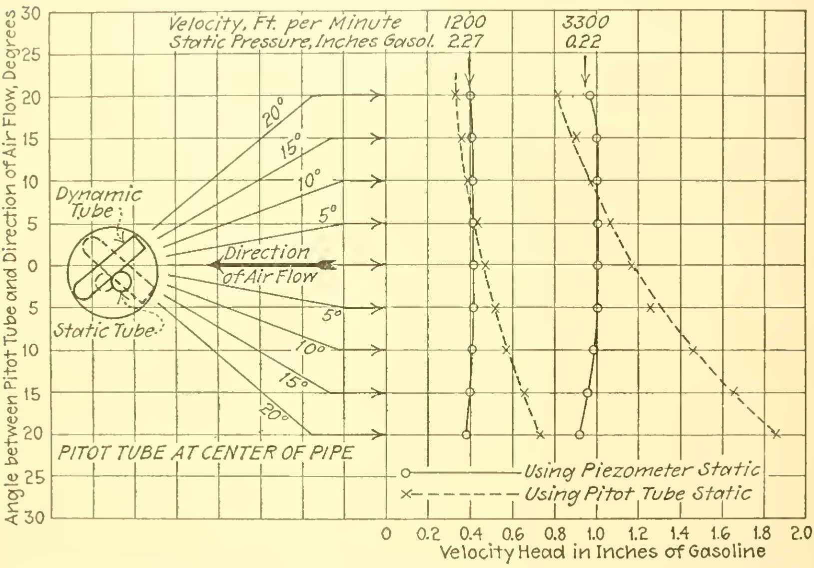


FIG. 16 PITOT TUBE *L*. DIAGRAM SHOWING THE EFFECT OF VARYING THE ANGLE BETWEEN THE PITOT TUBE AND THE DIRECTION OF AIR FLOW

1, of the manometers *B* and *C* used to find the pitot tube velocity heads, it will be seen that the manometer readings may be in error on the average as much as 1 per cent. Since the velocity of air flowing through the pipe varies as the square root of the velocity head, an error of 1 per cent in the velocity head means an error of ½ of 1 per cent in the velocity itself.

38 The accuracy of the measuring instruments used is much greater than can be expected from the pitot tube as a means of measuring gases, due to the uncontrollable variation in the air

flow. The considerations which may prevent even an absolutely correct pitot tube from giving true results are as follows:

a The air flows through the pipe in a wave or spiral motion and at no time is the velocity uniformly distributed across the pipe, being greater in one quarter than in the other three quarters: the quarter of highest velocities may or may not be on the diameters where pitot tube readings are being taken.

b The velocities on the diameters where pitot tube readings are being taken may be constantly varying during the period of time necessary to obtain the readings; thus the average of all readings may be slightly too large or too small.

c The air flow can only approach, never reach, the ideal conditions of parallel flow, and the pitot tube is correct, theoretically, only when the tube is exactly parallel to the current of air.

39 From these considerations, together with the author's experience in this line of work, it is estimated that the results obtained in measuring gases by an absolutely correct pitot tube may vary 1 per cent, more or less, from the correct results. Of course, the average of a large number of tests should be more nearly correct than this, for the plus errors will probably neutralize the minus errors.

40 The Thomas meter is not affected by any of these irregularities in air flow because the resistance thermometers in the form of screens across the gas passage automatically integrate the varying temperature differences resulting from heating a non-uniform current of gas or air (see Appendix No. 1).

CALCULATIONS

41 Not only was every precaution taken to obtain correct data, but the calculations were made with the same degree of refinement. Since the obtaining of accurate results by both the Thomas meter and the pitot tube depended upon the use of correct values of the properties of air, a thorough study was made of these. As a result of this study the author devised and constructed the large chart shown in Appendix No. 3, values taken from which agree almost exactly with the tables published by the Department of the Navy.[1] This chart is not only an exceedingly

[1] Dept. of Navy, Bureau of Construction and Repair. General Specifications, Appendix 8: Instructions for Calculating and Testing Ventilation System, 1908.

valuable aid in making calculations involving the properties of air, but it also presents these properties in what is thought to be a new graphical form. The basis of the calculations and the sources of information are given in the chart itself. The detailed calculations of the results of the experiments on pitot tubes are given in Appendix No. 2.

RESULTS

42 The results of the experiments on pitot tubes are presented in Tables 2 to 15 inclusive and graphically in Figs. 17 to 25 inclusive. In order that the tabulated results may be thoroughly understood a brief explanation is necessary.

43 The test number, Column 26, is given for purposes of identification and is further explained in Appendix No. 2. The cubic feet of air per minute by all three methods, i.e., by the Thomas meter, by the pitot tube alone and by the pitot dynamic tube together with the piezometer, are given in columns 28, 29, 30, and are all reduced to the conditions of temperature, pressure and humidity as determined at the section where the pitot tube is inserted.

44 Columns 31 to 35 inclusive are explained by their use in the following formulae:

$$C_1 = MC_2 \text{ or } M = \frac{C_1}{C_2}$$

$$C_1 = NC_3 \text{ or } N = \frac{C_1}{C_3}$$

$$C_3 = QC_2 \text{ or } Q = \frac{C_3}{C_2}$$

$$V_1 = \sqrt{2gh_1} = \sqrt{2gUh_3} \text{ or } U = \frac{h_1}{h_3}$$

$$V_2 = \sqrt{2gh_2} = \sqrt{2gZh_4} \text{ or } Z = \frac{h_2}{h_4}$$

where

C_1 = cu. ft. of air per minute by Thomas meter

C_2 = cu. ft. of air per minute by the pitot tube using the pitot static pressure

C_2 = cu. ft, of air per minute by the pitot tube using the

C_3 = cu. ft. of air per minute by pitot dynamic tube and the piezometer static pressure

V_1 and V_2 = velocity of the air flowing in ft. per sec.

h_1 = mean velocity head in ft. of air flowing, obtained by the pitot tube using the pitot static pressure

h_3 = velocity head in ft. of air at the center of the pipe obtained in the same manner as h_1

h_2 = mean velocity head in ft. of air flowing, obtained by the pitot dynamic tube and the piezometer static pressure

h_4 = velocity head in ft. of air at the center of the pipe, obtained in the same manner as h_2

45 *M* and *N* are therefore coefficients by which the actual results obtained by the pitot tube must be multiplied to obtain the correct flow of gas. *Q* gives the coefficient by which the results from the pitot tube alone must be multiplied to obtain the same discharge as that shown by the pitot dynamic tube and the piezometer. *U* and *Z* state the relations between the velocity head at the center of the pipe and the mean velocity head as determined by the two methods used in the experiments.

46 From a study of the summary, Table 2, the following general results and conclusions may be stated:

a The pitot tube as a means of measuring gases is reliable within approximately 1 per cent when the static pressure is correctly obtained and when all readings are taken with a sufficient degree of refinement; in order to obtain this degree of accuracy the pitot tube should be preceded by a length of pipe 20 to 38 times the pipe diameter in order to make the flow of gas as nearly uniform across the section of the pipe as possible.

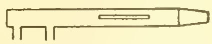
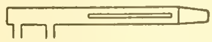
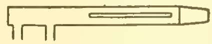
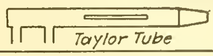
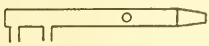
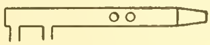
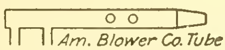
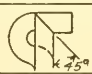
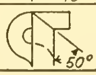
b All the methods of obtaining the dynamic head used in these experiments, including the Stauscheibe, give accurate results.

c The most reliable and accurate means of obtaining the static pressure is the piezometer or its equivalent, the results of 138 separate tests using the piezometer static pressure agreeing with the Thomas meter within an average of 0.33 per cent; these results show beyond any doubt that the static pressure is constant across any section of a pipe in which gas is flowing at a uniform rate.

d Of the methods of obtaining the static pressure by the pitot tube itself, the most reliable and accurate is by means of a very small hole in a perfectly smooth surface, as in pitot tube *Y*.

e The long slots for obtaining the static pressure are

TABLE 2 SUMMARY

	Name of Tube	*M*	*N*	*Q*	*U*	*Z*
	*A*	1.0614	1.0175	1.0413	0.7696	0.7936
	*B*	......	......	1.0576	0.8019	0.7898
	*C*	......	......	1.0343	0.7996	0.7880
	**C*	1.0346	0.9952	1.0384	0.8107	0.8066
 Thicker Outer Tube	*D*	......	......	1.0369	0.7927	0.7942
 Thickest Outer Tube	*E*	......	......	1.0489	0.7885	0.7898
 Taylor Tube	*X*	1.0987	0.9925	1.1074	0.7696	0.7867
	*G*	1.0076	1.0085	0.9989	0.8100	0.8164
	*H*	1.0218	1.0152	1.0065	0.7966	0.7957
 Am. Blower Co. Tube	*Y*	1.0024	1.0017	0.9992	0.8002	0.7996
 45°	*K*	1.0669	0.9924	1.0626	0.7617	0.8115
 50°	*L*	1.0104	1.0032	1.0064	0.7593	0.8112
Average		......	1.0033	......	0.7884	0.7986
 Stauscheibe	*S*	0.9861	1.0016	0.9844	0.7780	0.8228

not reliable and give results which are in error from 3.5 to 10 per cent. The fact that slots do not give correct results is further illustrated by Fig. 15. The length of the slots or the thickness of the outer tube do not appear to affect the accuracy of the tube.

f The beveled tube for obtaining the static pressure as used in pitot tubes *K* and *L* is not reliable. A very slight change in the angle of bevel produces an appreciable change in the result. In taking a traverse of a pipe the sides of the pipe affect the readings. But the greatest error is produced by the uncertainty as to whether the tube is pointing directly upstream. The effect of allowing the tube to point at an angle with the direction of flow is shown by Fig. 16, where it is seen that if the tube is off 20 deg. in one direction an error of 85 per cent in the velocity head is introduced.

g The Stauscheibe gives accurate results using either the static reading from the Stauscheibe and the special formula (Par. 79); or by using the piezometer static with the usual formula for the pitot tubes. In the first case the agreement is within 1.4 per cent and in the second within 0.16 per cent, as shown in Table 15 and Fig. 25.

h It appears that an approximate relation exists between the mean velocity head of a gas flowing through the pipe and the velocity head found by placing the tube at the center of the pipe. For a 12-in. galvanized iron pipe results within 2 per cent may be expected from using the formula

$$v = \sqrt{(2g)\ (0.80)\ h_c}$$

where

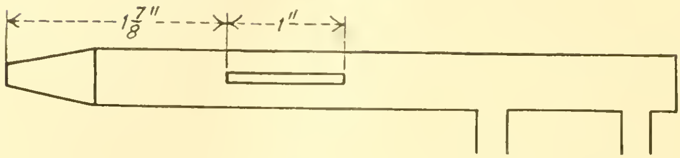
v = velocity in ft. per second

g = 32.2 ft. per second per second

h_c = velocity head in in. of gasolene at the center of the pipe obtained in a correct manner

47 The writer wishes to acknowledge the valuable help and suggestions given by Professors Carl. C. Thomas and A. G. Christie of the University of Wisconsin, and by Mr. J. C. Wilson, whose untiring interest made possible the success of these experiments. He also wishes to acknowledge his indebtedness to Mr. F. Lorig, who aided in obtaining much of the data, and to others who loaned or contributed apparatus or suggestions.

TABLE 3 RESULTS OF PITOT TUBE *A*



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			*M*	*N*	*Q*	*U*	*Z*
		Thomas Meter C_1	Pitot Tube						
			Using Pitot Static C_2	Using Piezometer Static C_3	$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	$\frac{\text{Col. 18}}{\text{Col. 20}}$	$\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
A–1–F	795	1710	1655	1680	1.043	1.017	1.015	0.773	0.790
A–2–F	870	1910	1828	1870	1.055	1.021	1.023	0.748	0.788
A–3–F	947	2085	1995	2058	1.045	1.013	1.030	0.767	0.789
A–4–F	1031	2265	2160	2237	1.047	1.013	1.034	0.769	0.784
A–5–F	1118	2487	2340	2440	1.063	1.019	1.043	0.768	0.792
A–6–F	1191	2675	2513	2620	1.064	1.020	1.043	0.775	0.793
A–7–F	1273	2885	2685	2805	1.074	1.028	1.044	0.773	0.788
A–8–F	1370	3095	2880	3005	1.074	1.029	1.044	0.780	0.787
A–9–F	1458	3300	3080	3240	1.070	1.017	1.051	0.788	0.798
Average..	....	....	....	....	1.0595	1.0197	1.0363	0.7712	0.7900
A–1–½	794	1080	1036	1068	1.049	1.010	1.037	0.775	0.813
A–2–½	875	1178	1138	1171	1.035	1.005	1.030	0.772	0.793
A–3–½	951	1315	1240	1280	1.059	1.026	1.032	0.772	0.778
A–4–½	1028	1420	1371	1399	1.035	1.014	1.020	0.793	0.792
A–5–½	1107	1552	1452	1510	1.068	1.025	1.040	0.752	0.780
A–6–½	1190	1673	1573	1662	1.063	1.005	1.056	0.775	0.810
A–7–½	1266	1803	1663	1770	1.090	1.023	1.064	0.765	0.798
A–8–½	1371	1942	1782	1902	1.090	1.020	1.066	0.768	0.805
A–9–½	1447	2049	1892	2030	1.083	1.010	1.072	0.760	0.805
Average..........		....	....	....	1.0633	1.0153	1.0463	0.7680	0.7971
Net Average......		....	....	....	1.0614	1.0175	1.0413	0.7696	0.7936

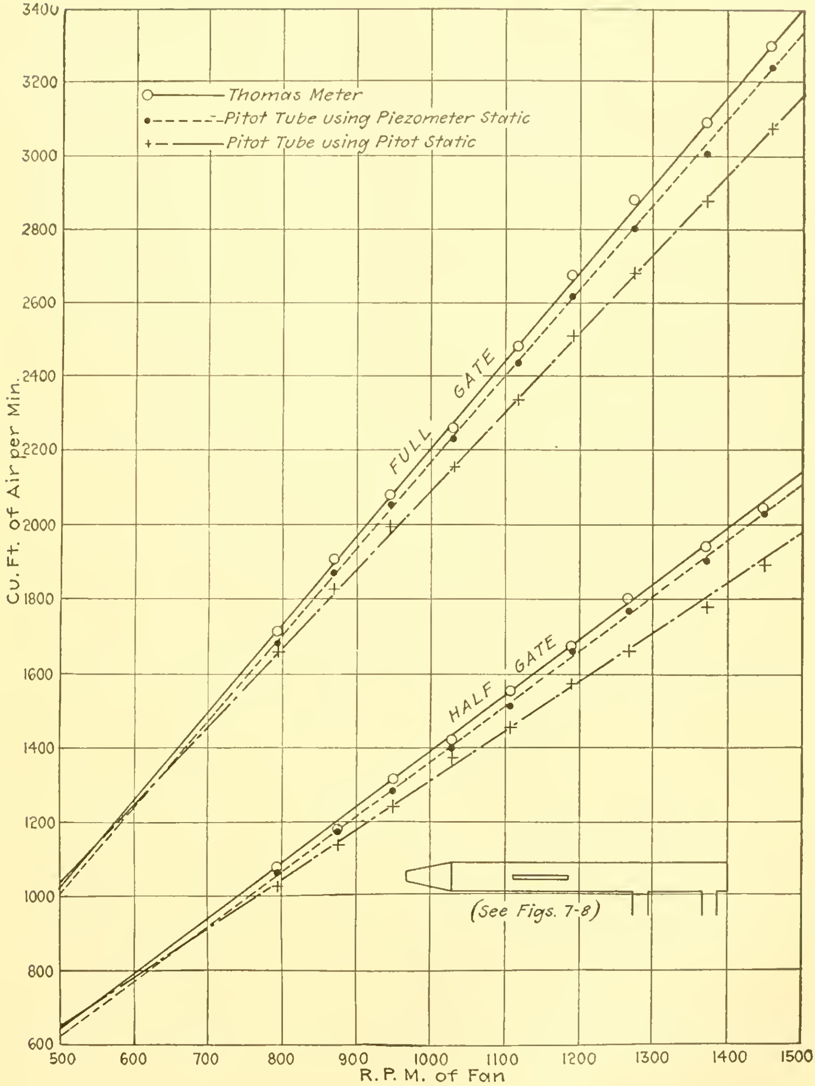
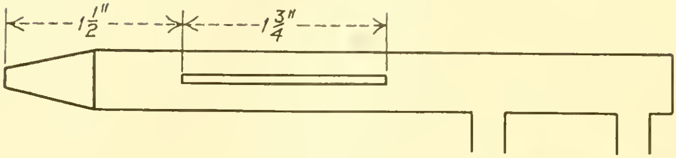


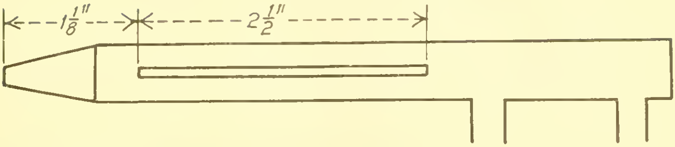
Fig. 17 Pitot Tube *A*

TABLE 4 RESULTS OF PITOT TUBE *B*



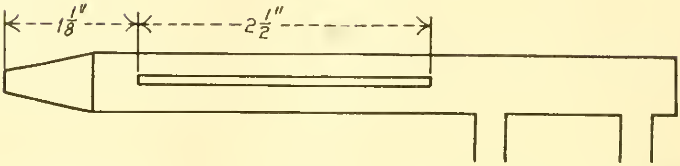
Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			M	N	Q	U	Z
		Thomas Meter C_1	Pitot Tube						
			Using Pitot Static C_2	Using Piezometer Static C_3	$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	$\frac{\text{Col. 18}}{\text{Col. 20}}$	$\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
B–1–F	780	....	1622	1714	.....	.....	1.056	0.802	0.792
B–2–F	877	....	1792	1889	.....	.....	1.053	0.802	0.780
B–3–F	944	....	1960	2080	.....	.....	1.061	0.798	0.788
B–4–F	1023	....	2140	2265	.....	.....	1.058	0.797	0.779
B–5–F	1110	....	2317	2470	.....	.....	1.058	0.800	0.790
B–6–F	1194	....	2488	2660	.....	.....	1.068	0.808	0.792
B–7–F	1275	....	2650	2835	.....	.....	1.069	0.812	0.787
B–8–F	1375	....	2820	3040	.....	.....	1.076	0.813	0.793
B–9–F	1458	....	3007	3240	.....	.....	1.076	0.815	0.795
Average..	....	....	....	....	.....	.....	1.0639	0.8052	0.7885
B–1–½	784	....	1020	1050	.....	.....	1.030	0.786	0.788
B–2–½	870	....	1118	1163	.....	.....	1.039	0.784	0.782
B–3–½	950	....	1217	1280	.....	.....	1.050	0.788	0.802
B–4–½	1030	....	1318	1377	.....	.....	1.045	0.792	0.778
B–5–½	1104	....	1432	1508	.....	.....	1.053	0.813	0.798
B–6–½	1185	....	1540	1628	.....	.....	1.057	0.810	0.790
B–7–½	1266	....	1648	1740	.....	.....	1.056	0.805	0.785
B–8–½	1348	....	1760	1875	.....	.....	1.064	0.810	0.798
B–9–½	1447	....	1883	2010	.....	.....	1.068	0.809	0.797
Average..........		....	....	....	.....	.....	1.0513	0.7986	0.7910
Net Average......		....	....	....	.....	.....	1.0576	0.8019	0.7898

TABLE 5 RESULTS OF PITOT TUBE *C*



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			M	N	Q	U	Z
		Thomas Meter C_1	Pitot Tube						
			Using Pitot Static C_2	Using Piezometer Static C_3	$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	$\frac{\text{Col. 18}}{\text{Col. 20}}$	$\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
C-1-F	790	....	1623	1672	.....	.....	1.030	0.793	0.777
C-2-F	872	....	1793	1860	.....	.....	1.036	0.793	0.762
C-3-F	950	....	1975	2042	.....	.....	1.034	0.807	0.795
C-4-F	1030	....	2160	2228	.....	.....	1.032	0.800	0.782
C-5-F	1124	....	2348	2432	.....	.....	1.034	0.804	0.789
C-6-F	1198	....	2505	2600	.....	.....	1.038	0.799	0.786
C-7-F	1289	....	2685	2780	.....	.....	1.034	0.803	0.789
C-8-F	1378	....	2870	2987	.....	.....	1.041	0.806	0.793
C-9-F	1466	....	3065	3195	.....	.....	1.042	0.804	0.793
Average..	....	....	....	....	.....	.....	1.0357	0.8010	0.7847
C-1-½	793	....	1024	1044	.....	.....	1.020	0.800	0.785
C-2-½	866	....	1131	1150	.....	.....	1.016	0.796	0.781
C-3-½	947	....	1239	1268	.....	.....	1.023	0.796	0.788
C-4-½	1033	....	1340	1380	.....	.....	1.031	0.807	0.793
C-5-½	1115	....	1450	1505	.....	.....	1.038	0.800	0.794
C-6-½	1194	....	1562	1620	.....	.....	1.038	0.797	0.789
C-7-½	1271	....	1672	1737	.....	.....	1.038	0.795	0.790
C-8-½	1360	....	1800	1872	.....	.....	1.041	0.798	0.795
C-9-½	1450	....	1920	2015	.....	.....	1.050	0.802	0.806
Average...........		....	....	....	.....	.....	1.0328	0.7983	0.7912
Net Average......		....	....	....	.....	.....	1.0343	0.7996	0.7880

TABLE 6 RESULTS OF PITOT TUBE *C



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min. — Thomas Meter C_1	Pitot Tube — Using Pitot Static C_2	Pitot Tube — Using Piezometer Static C_3	M $\frac{C_1}{C_2}$	N $\frac{C_1}{C_3}$	Q $\frac{C_3}{C_2}$	U $\frac{\text{Col. 18}}{\text{Col. 20}}$	Z $\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
*C–1–F	...	....	....	....	.....	.....	.....	.....	.....
*C–2–F	850	1693	1657	1708	1.022	0.992	1.030	0.809	0.794
*C–3–F	915	1850	1818	1872	1.018	0.989	1.030	0.801	0.792
*C–4–F	994	2025	1970	2039	1.027	0.993	1.033	0.809	0.803
*C–5–F	1068	2202	2133	2210	1.032	0.996	1.034	0.808	0.800
*C–6–F	1150	2370	2297	2385	1.033	0.994	1.037	0.813	0.804
*C–7–F	1214	2540	2468	2560	1.029	0.994	1.036	0.817	0.808
*C–8–F	1290	2720	2633	2740	1.033	0.994	1.040	0.814	0.806
*C–9–F	1385	2935	2820	2955	1.040	0.994	1.027	0.815	0.812
Average..	....	....	....	....	1.0292	0.9932	1.0336	0.8107	0.8024
*C–1–½	...	....	....	....	.....	.....	.....	.....	.....
*C–2–½	847	1143	1105	1126	1.033	1.015	1.020	0.807	0.807
*C–3–½	914	1233	1202	1239	1.025	0.996	1.030	0.808	0.805
*C–4–½	987	1326	1290	1340	1.029	0.990	1.037	0.808	0.803
*C–5–½	1066	1440	1386	1448	1.040	0.996	1.044	0.817	0.813
*C–6–½	1145	1544	1479	1553	1.044	0.995	1.049	0.817	0.817
*C–7–½	1214	1643	1575	1658	1.043	0.992	1.052	0.808	0.808
*C–8–½	1298	1773	1675	1780	1.058	0.996	1.063	0.802	0.818
*C–9–½	1386	1885	1800	1890	1.047	0.998	1.050	0.818	0.815
Average...........		....	....	....	1.0399	0.9972	1.0431	0.8106	0.8107
Net Average......		....	....	....	1.0346	0.9952	1.0384	0.8107	0.8066

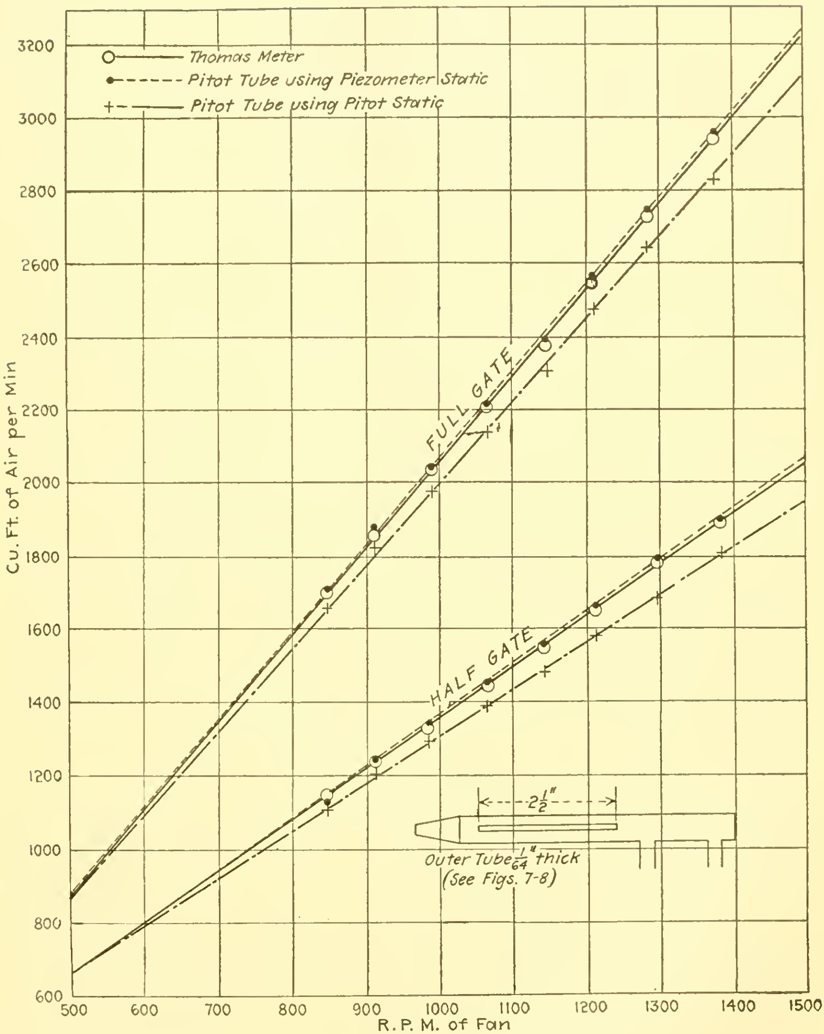
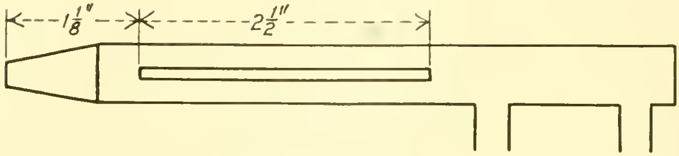


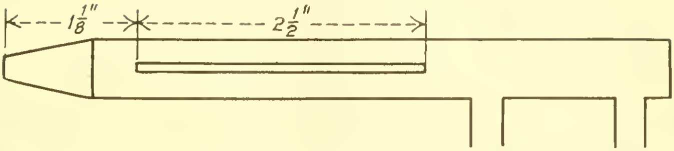
FIG. 18 PITOT TUBE* *C*

TABLE 7 RESULTS OF PITOT TUBE *D*



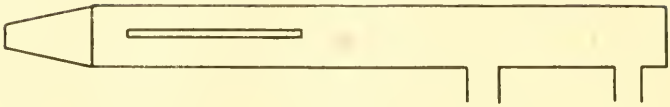
Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min. Thomas Meter C_1	Pitot Tube Using Pitot Static C_2	Pitot Tube Using Piez-ometer Static C_3	M $\frac{C_1}{C_2}$	N $\frac{C_1}{C_3}$	Q $\frac{C_3}{C_2}$	U $\frac{\text{Col. 18}}{\text{Col. 20}}$	Z $\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
D-1-F	792	....	1583	1620	.....	.....	1.024	0.779	0.754
D-2-F	873	....	1752	1805	.....	.....	1.030	0.789	0.777
D-3-F	954	....	1932	2005	.....	.....	1.037	0.790	0.792
D-4-F	1029	....	2100	2160	.....	.....	1.028	0.793	0.781
D-5-F	1118	....	2295	2367	.....	.....	1.031	0.792	0.781
D-6-F	1202	....	2470	2550	.....	.....	1.032	0.795	0.788
D-7-F	1283	....	2660	2750	.....	.....	1.033	0.796	0.790
D-8-F	1377	....	2850	2950	.....	.....	1.034	0.798	0.792
D-9-F	1465	....	3045	3150	.....	.....	1.035	0.798	0.798
Average........		....	....	....	.....	.....	.....	.....	.....
D-1-½	792	....	984	1019	.....	.....	1.035	0.772	0.782
D-2-½	871	....	1097	1127	.....	.....	1.034	0.787	0.790
D-3-½	955	....	1200	1254	.....	.....	1.045	0.795	0.808
D-4-½	1030	....	1303	1348	.....	.....	1.035	0.790	0.786
D-5-½	1121	....	1431	1487	.....	.....	1.039	0.812	0.807
D-6-½	1204	....	1526	1593	.....	.....	1.043	0.795	0.792
D-7-½	1290	....	1635	1710	.....	.....	1.045	0.798	0.796
D-8-½	1379	....	1760	1850	.....	.....	1.050	0.793	0.795
D-9-½	1473	....	1880	1985	.....	.....	1.054	0.796	0.796
Average...........		....	....	....	.....	.....	1.0422	0.7931	0.7947
Net Average......		....	....	....	.....	.....	1.0369	0.7927	0.7942

TABLE 8 RESULTS OF PITOT TUBE *E*



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			M	N	Q	U	Z
		Thomas Meter C_1	Pitot Tube		$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	$\frac{\text{Col. 18}}{\text{Col. 20}}$	$\frac{\text{Col. 19}}{\text{Col. 21}}$
			Using Pitot Static C_2	Using Piezometer Static C_3					
26	27	28	29	30	31	32	33	34	35
E-1-F	790	....	1577	1626	.....	.....	1.031	0.774	0.779
E-2-F	872	....	1730	1797	.....	.....	1.039	0.779	0.781
E-3-F	951	....	1895	1975	.....	.....	1.042	0.783	0.786
E-4-F	1031	....	2060	2153	.....	.....	1.044	0.790	0.791
E-5-F	1116	....	2242	2355	.....	.....	1.050	0.787	0.787
E-6-F	1202	....	2418	2543	.....	.....	1.053	0.788	0.788
E-7-F	1282	....	2592	2735	.....	.....	1.054	0.788	0.790
E-8-F	1380	....	2850	2960	.....	.....	1.039	0.792	0.793
E-9-F	1465	....	3050	3155	.....	.....	1.033	0.791	0.795
Average........		....	....	....	.....	.....	1.0429	0.7859	0.7879
E-1-½	792	....	1008	1057	.....	.....	1.050	0.790	0.805
E-2-½	873	....	1130	1176	.....	.....	1.040	0.788	0.802
E-3-½	952	....	1224	1276	.....	.....	1.042	0.785	0.799
E-4-½	1030	....	1324	1385	.....	.....	1.046	0.785	0.795
E-5-½	1117	....	1440	1515	.....	.....	1.052	0.788	0.803
E-6-½	1201	....	1543	1630	.....	.....	1.056	0.790	0.798
E-7-½	1284	....	1655	1760	.....	.....	1.063	0.790	0.797
E-8-½	1378	....	1777	1895	.....	.....	1.065	0.800	0.808
E-9-½	1468	....	1890	2040	.....	.....	1.079	0.803	0.818
Average..........		....	....	....	.....	.....	1.0549	0.7910	0.7917
Net Average......		....	....	....	.....	.....	1.0489	0.7885	0.7898

TABLE 9 RESULTS OF PITOT TUBE X



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			M	N	Q	U	Z
		Thomas Meter C_1	Pitot Tube		$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	$\frac{\text{Col. 18}}{\text{Col. 20}}$	$\frac{\text{Col. 19}}{\text{Col. 21}}$
			Using Pitot Static C_2	Using Piezometer Static C_3					
26	27	28	29	30	31	32	33	34	35
X-1-F	807	1605	1510	1650	1.062	0.973	1.092	0.798	0.790
X-2-F	888	1800	1655	1825	1.087	0.987	1.102	0.794	0.793
X-3-F	963	1962	1805	2000	1.087	0.982	1.108	0.793	0.795
X-4-F	1046	2140	1975	2180	1.083	0.983	1.103	0.793	0.788
X-5-F	1135	2345	2125	2380	1.102	0.985	1.120	0.770	0.793
X-6-F	1229	2545	2280	2562	1.115	0.993	1.123	0.775	0.792
X-7-F	1311	2745	2455	2740	1.117	1.002	1.116	0.772	0.779
X-8-F	1410	2940	2625	2970	1.120	0.991	1.130	0.774	0.800
X-9-F	1496	3145	2785	3165	1.128	0.993	1.135	0.777	0.798
Average..	....	....	....	....	1.1001	0.9877	1.1143	0.7830	0.7920
X-1-½	785	1047	958	1037	1.093	1.010	1.083	0.738	0.767
X-2-½	876	1161	1060	1153	1.095	1.007	1.088	0.751	0.788
X-3-½	954	1270	1156	1260	1.098	1.007	1.090	0.757	0.790
X-4-½	1028	1378	1256	1380	1.098	0.999	1.098	0.755	0.780
X-5-½	1120	1490	1363	1488	1.094	1.001	1.093	0.755	0.770
X-6-½	1195	1595	1457	1609	1.095	0.992	1.103	0.758	0.790
X-7-½	1288	1713	1557	1723	1.100	0.994	1.105	0.760	0.782
X-8-½	1370	1834	1670	1870	1.099	0.983	1.120	0.765	0.772
X-9-½	1460	1960	1775	1996	1.103	0.983	1.124	0.767	0.793
Average...........		....	....	....	1.0972	0.9973	1.1004	0.7562	0.7813
Net Average......		....	....	....	1.0987	0.9925	1.1074	0.7696	0.7867

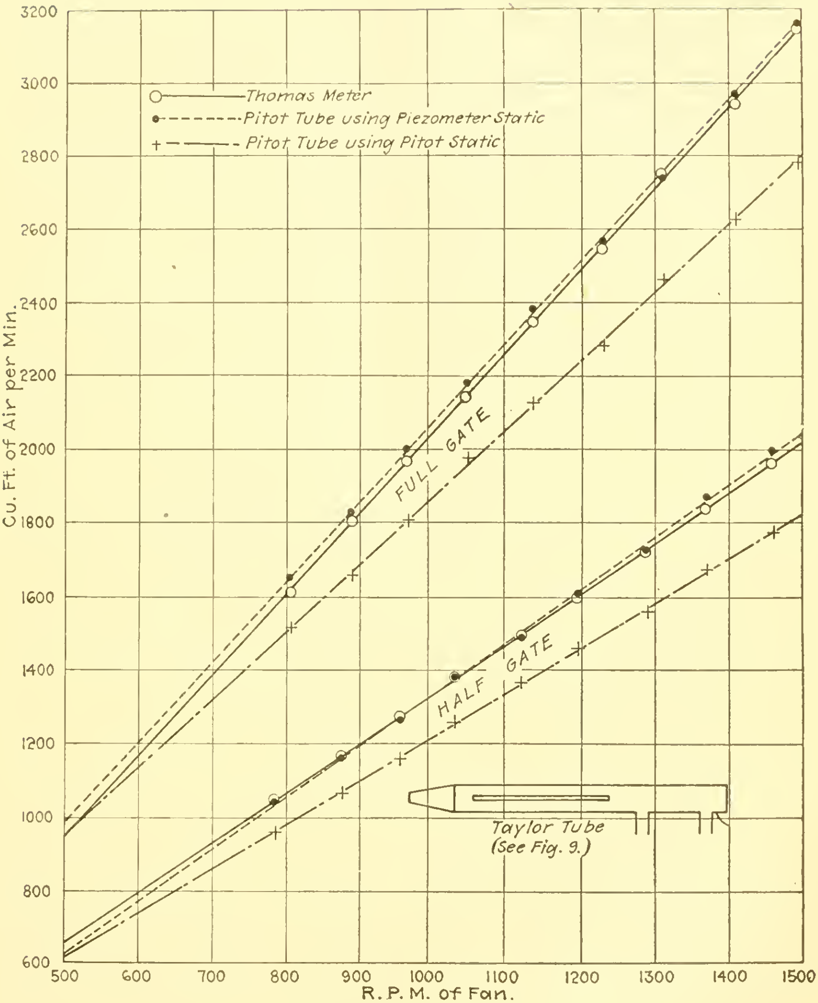
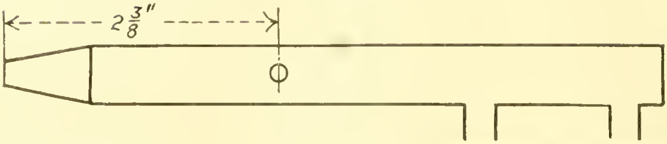


FIG. 19 PITOT TUBE *X*

TABLE 10 RESULTS OF PITOT TUBE *G*



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			*M*	*N*	*Q*	*U*	*Z*
		Thomas Meter C_1	Pitot Tube						
			Using Pitot Static C_2	Using Piezometer Static C_3	$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	Col. 18 / Col. 20	Col. 19 / Col. 21
26	27	28	29	30	31	32	33	34	35
G–1–F	760	1590	1556	1550	1.021	1.026	0.997	0.798	0.806
G–2–F	835	1764	1722	1716	1.023	1.027	0.997	0.792	0.797
G–3–F	912	1912	1882	1870	1.021	1.022	0.994	0.811	0.812
G–4–F	984	2060	2032	2027	1.013	1.014	0.998	0.803	0.793
G–5–F	1060	2220	2220	2215	1.000	1.002	0.998	0.802	0.797
G–6–F	1128	2406	2370	2370	1.014	1.014	1.000	0.802	0.812
G–7–F	1202	2543	2537	2535	1.003	1.003	0.999	0.811	0.817
G–8–F	1278	2718	2718	2715	1.000	1.000	0.999	0.813	0.822
G–9–F	1356	2910	2895	2900	1.004	1.003	1.002	0.812	0.822
Average..	....	....	....	....	1.0110	1.0123	0.9982	0.8049	0.8097
G–1–½	....	....	....	....	.....	.....	.....	.....	.....
G–2–½	836	1124	1135	1114	0.992	1.009	0.982	0.811	0.812
G–3–½	900	1217	1240	1227	0.982	0.993	0.991	0.805	0.814
G–4–½	988	1343	1331	1323	1.007	1.013	0.993	0.812	0.818
G–5–½	1060	1439	1435	1430	1.002	1.006	0.998	0.809	0.813
G–6–½	1135	1554	1538	1544	1.010	1.006	1.003	0.813	0.823
G–7–½	1210	1663	1632	1640	1.017	1.013	1.004	0.811	0.821
G–8–½	1288	1769	1753	1772	1.009	0.998	1.010	0.822	0.834
G–9–½	1370	1883	1870	1885	1.005	0.999	1.006	0.837	0.849
Average...........		....	....	....	1.0042	1.0046	0.9995	0.8150	0.8230
Net Average......		....	....	....	1.0076	1.0085	0.9989	0.8100	0.8164

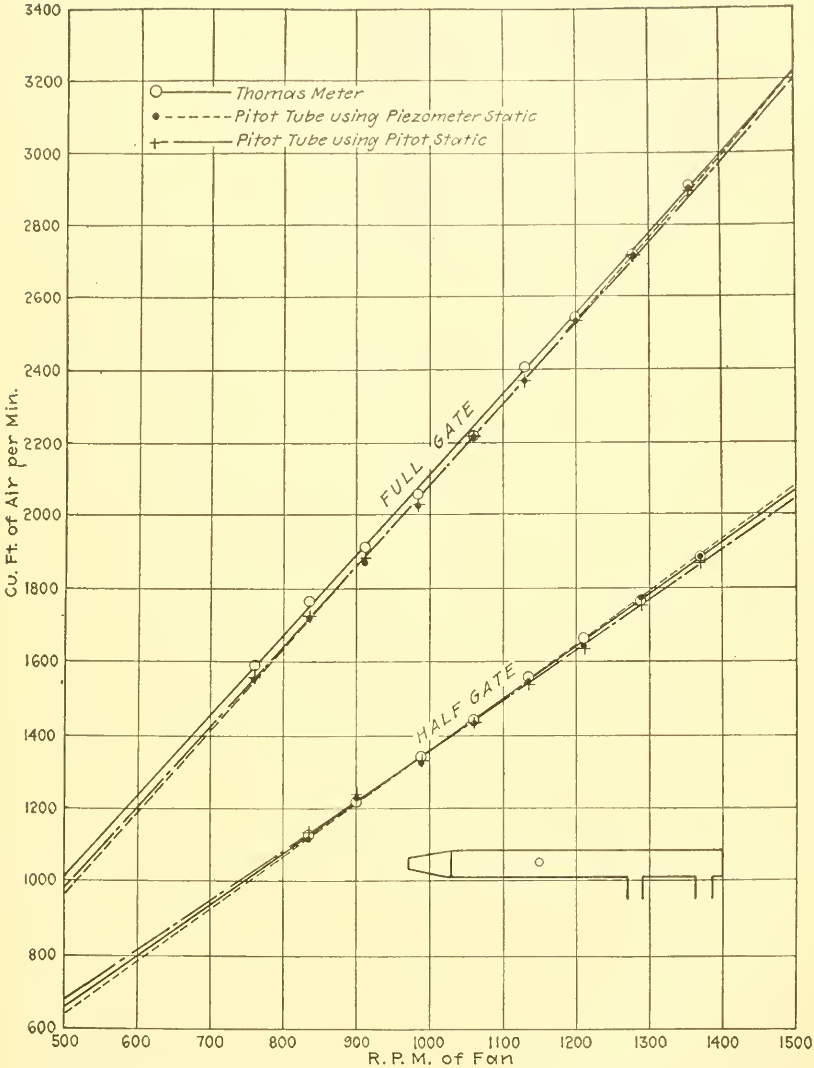
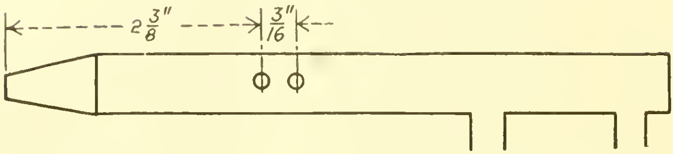


FIG. 20 PITOT TUBE *G*

TABLE 11 RESULTS OF PITOT TUBE *H*



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			M	N	Q	U	Z
		Thomas Meter C_2	Pitot Tube						
			Using Pitot Static C_2	Using Piezometer Static C_3	$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	$\frac{\text{Col. 18}}{\text{Col. 20}}$	$\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
H-1-F	....	....	....	....	.....	.....	.....	.....	.....
H-2-F	872	1930	1922	1912	1.003	1.008	0.998	0.803	0.798
H-3-F	947	2108	2123	2123	0.993	0.993	1.000	0.830	0.826
H-4-F	1024	2300	2275	2269	1.010	1.013	0.998	0.796	0.790
H-5-F	1110	2508	2465	2463	1.017	1.018	0.999	0.795	0.792
H-6-F	1195	2710	2656	2653	1.016	1.017	0.999	0.792	0.790
H-7-F	1273	2910	2855	2855	1.019	1.019	1.000	0.799	0.798
H-8-F	1375	3120	3062	3060	1.018	1.019	0.999	0.800	0.800
H-9-F	1456	3330	3265	3270	1.019	1.018	1.001	0.798	0.803
Average..	....	....	....	....	1.0120	1.0131	0.9992	0.8016	0.7996
H-1-½	....	....	....	....	.....	.....	.....	.....	.....
H-2-½	870	1203	1170	1176	1.026	1.023	1.006	0.788	0.793
H-3-½	948	1313	1274	1284	1.028	1.021	1.007	0.775	0.780
H-4-½	1029	1425	1390	1403	1.025	1.015	1.010	0.787	0.787
H-5-½	1110	1570	1523	1535	1.030	1.022	1.007	0.802	0.791
H-6-½	1185	1685	1623	1654	1.036	1.018	1.020	0.797	0.795
H-7-½	1265	1793	1738	1763	1.032	1.016	1.013	0.796	0.791
H-8-½	1360	1932	1870	1910	1.033	1.010	1.021	0.798	0.801
H-9-½	1454	2072	1986	2040	1.043	1.013	1.026	0.789	0.796
Average...........		....	....	....	1.0316	1.0172	1.0137	0.7915	0.7917
Net Average......		....	....	....	1.0218	1.0152	1.0065	0.7966	0.7957

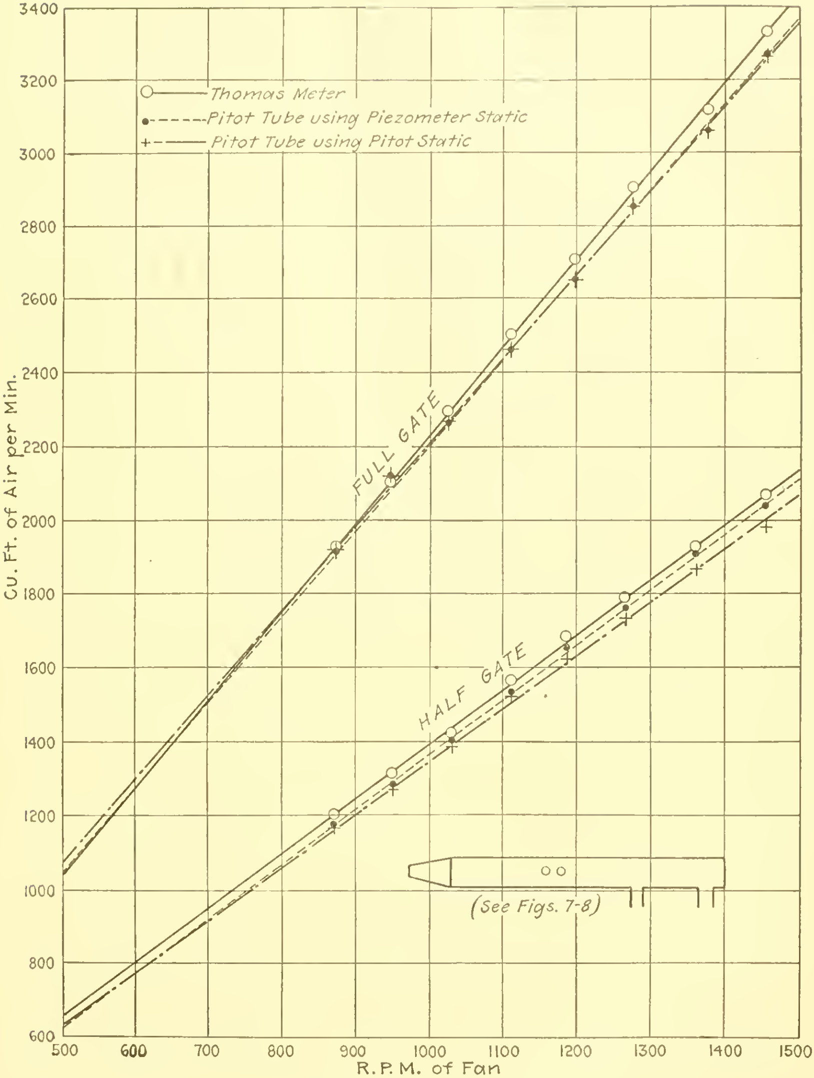
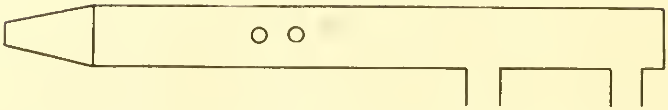


Fig. 21 Pitot Tube *H*

TABLE 12 RESULTS OF PITOT TUBE *Y*



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			*M*	*N*	*Q*	*U*	*Z*
		Thomas Meter C_1	Pitot Tube						
			Using Pitot Static C_2	Using Piezometer Static C_3	$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	$\frac{\text{Col. 18}}{\text{Col. 20}}$	$\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
Y-1-F	793	1635	1652	1650	0.991	0.992	0.999	0.800	0.813
Y-2-F	887	1865	1860	1860	1.002	1.002	1.000	0.799	0.808
Y-3-F	968	2033	2032	2030	1.000	1.001	0.999	0.803	0.796
Y-4-F	1050	2215	2215	2205	1.000	1.003	0.997	0.797	0.812
Y-5-F	1144	2424	2425	2422	1.000	1.001	0.999	0.801	0.795
Y-6-F	1226	2606	2608	2595	0.999	1.003	0.996	0.805	0.797
Y-7-F	1316	2800	2800	2790	1.000	1.003	0.998	0.806	0.802
Y-8-F	1409	3035	3010	2990	1.007	1.014	0.993	0.808	0.797
Y-9-F	1490	3220	3215	3195	1.001	1.007	0.994	0.806	0.798
Average..	....	....	....	....	1.000	1.0029	0.9951	0.8027	0.8020
Y-1-½	786	1025	1040	1040	0.986	0.986	1.000	0.791	0.794
Y-2-½	876	1160	1152	1152	1.007	1.007	1.000	0.797	0.790
Y-3-½	952	1271	1267	1267	1.004	1.003	0.999	0.800	0.795
Y-4-½	1026	1382	1380	1381	1.001	1.000	1.000	0.798	0.795
Y-5-½	1113	1510	1503	1508	1.004	1.001	1.003	0.802	0.802
Y-6-½	1195	1636	1620	1630	1.009	1.003	1.004	0.803	0.802
Y-7-½	1287	1756	1740	1750	1.009	1.003	1.004	0.798	0.796
Y-8-½	1370	1895	1872	1886	1.011	1.004	1.006	0.799	0.799
Y-9-½	1462	2015	1990	2020	1.012	0.998	0.014	0.802	0.802
Average...........		....	....	....	1.0048	1.0005	1.0033	0.7990	0.7972
Net Average......		....	....	....	1.0024	1.0017	0.9992	0.8002	0.7996

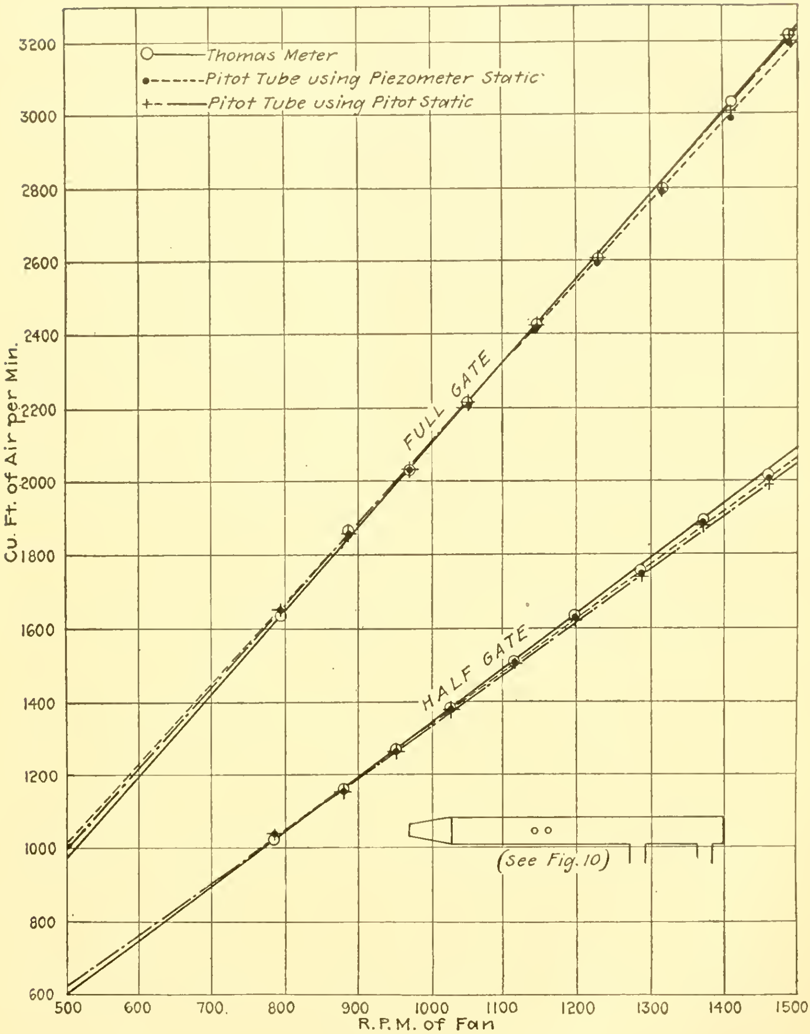


Fig. 22 Pitot Tube Y

TABLE 13 RESULTS OF PITOT TUBE *K*

Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			M	N	Q	U	Z
		Thomas Meter C_1	Pitot Tube: Using Pitot Static C_2	Pitot Tube: Using Piezometer Static C_3	$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	$\frac{\text{Col. 18}}{\text{Col. 20}}$	$\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
K–1–F	....	....	....	....	.....	.....	.....	.....	.....
K–2–F	840	1707	1542	1673	1.107	1.020	1.085	0.773	0.808
K–3–F	910	1863	1675	1826	1.112	1.019	1.090	0.767	0.810
K–4–F	985	2020	1832	1985	1.102	1.017	1.083	0.771	0.813
K–5–F	1060	2186	2003	2160	1.091	1.012	1.077	0.763	0.818
K–6–F	1140	2363	2162	2308	1.091	1.022	1.067	0.788	0.822
K–7–F	1215	2527	2310	2480	1.093	1.018	1.073	0.762	0.802
K–8–F	1295	2695	2487	2672	1.083	1.009	1.073	0.762	0.818
K–9–F	1375	2850	2660	2842	1.070	1.003	1.068	0.763	0.797
Average........		....	....	....	1.0936	1.0150	1.0770	0.7686	0.8110
K–1–½	....	....	....	....	.....	.....	.....	.....	.....
K–2–½	828	1077	1063	1098	1.015	0.983	1.033	0.758	0.808
K–3–½	900	1192	1147	1193	1.039	1.000	1.038	0.745	0.805
K–4–½	982	1307	1240	1294	1.054	1.010	1.043	0.752	0.814
K–5–½	1070	1405	1338	1413	1.050	0.995	1.054	0.758	0.815
K–6–½	1140	1498	1441	1510	1.040	0.993	1.047	0.752	0.806
K–7–½	1216	1581	1518	1595	1.042	0.992	1.050	0.752	0.812
K–8–½	1295	1675	1620	1728	1.033	0.971	1.067	0.760	0.819
K–9–½	1377	1802	1720	1812	1.048	0.995	1.053	0.761	0.817
Average...........		....	....	....	1.0401	0.9924	1.0481	0.7548	0.8120
Net Average......		....	....	....	1.0669	1.0037	1.0626	0.7617	0.8115

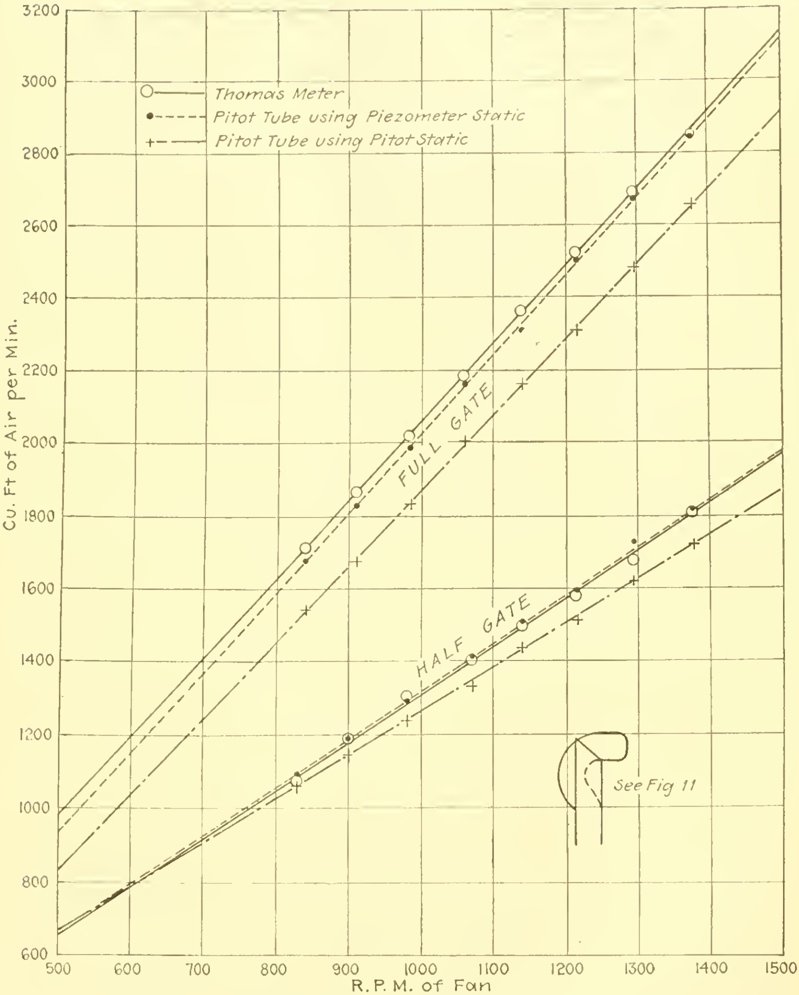
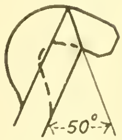


Fig. 23 Pitot Tube *K*

TABLE 14 RESULTS OF PITOT TUBE *L*



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min.			M	N	Q	U	Z
		Thomas Meter C_1	Pitot Tube: Using Pitot Static C_2	Pitot Tube: Using Piezometer Static C_3	$\frac{C_1}{C_2}$	$\frac{C_1}{C_3}$	$\frac{C_3}{C_2}$	Col. 18 / Col. 20	Col. 19 / Col. 21
26	27	28	29	30	31	32	33	34	35
L–1–F	....	....	....	....	.....	.....	.....	.....	.....
L–2–F	838	1733	1678	1684	1.032	1.028	1.003	0.758	0.815
L–3–F	....	....	....	....	.....	.....	.....	.....	.....
L–4–F	980	2010	1980	1993	1.014	1.007	1.006	0.757	0.798
L–5–F	1060	2200	2145	2165	1.025	1.015	1.009	0.748	0.806
L–6–F	1140	2357	2318	2335	1.016	1.008	1.007	0.753	0.810
L–7–F	1210	2517	2470	2492	1.017	1.009	1.007	0.737	0.802
L–8–F	1295	2700	2672	2685	1.010	1.004	1.004	0.757	0.809
L–9–F	1365	2878	2833	2870	1.015	1.002	1.013	0.752	0.812
Average..	....	....	....	....	1.0178	1.0104	1.0068	0.7517	0.8074
L–1–½	....	....	....	....	.....	.....	.....	.....	.....
L–2–½	828	1100	1120	1105	0.982	0.996	0.987	0.775	0.805
L–3–½	900	1209	1208	1213	1.000	0.997	1.002	0.769	0.816
L–4–½	970	1296	1300	1306	0.997	0.993	1.004	0.772	0.817
L–5–½	1055	1402	1402	1418	1.000	0.989	1.010	0.762	0.807
L–6–½	1127	1522	1500	1519	1.013	1.002	1.011	0.765	0.820
L–7–½	1210	1628	1609	1625	1.013	1.002	1.010	0.772	0.822
L–8–½	1290	1721	1710	1734	1.006	0.993	1.013	0.758	0.810
L–9–½	1360	1838	1815	1845	1.012	0.997	1.016	0.761	0.822
Average...........		....	....	....	1.0030	0.996	1.0060	0.7668	0.8150
Net Average......		....	....	....	1.0104	1.0032	1.0064	0.7593	0.8112

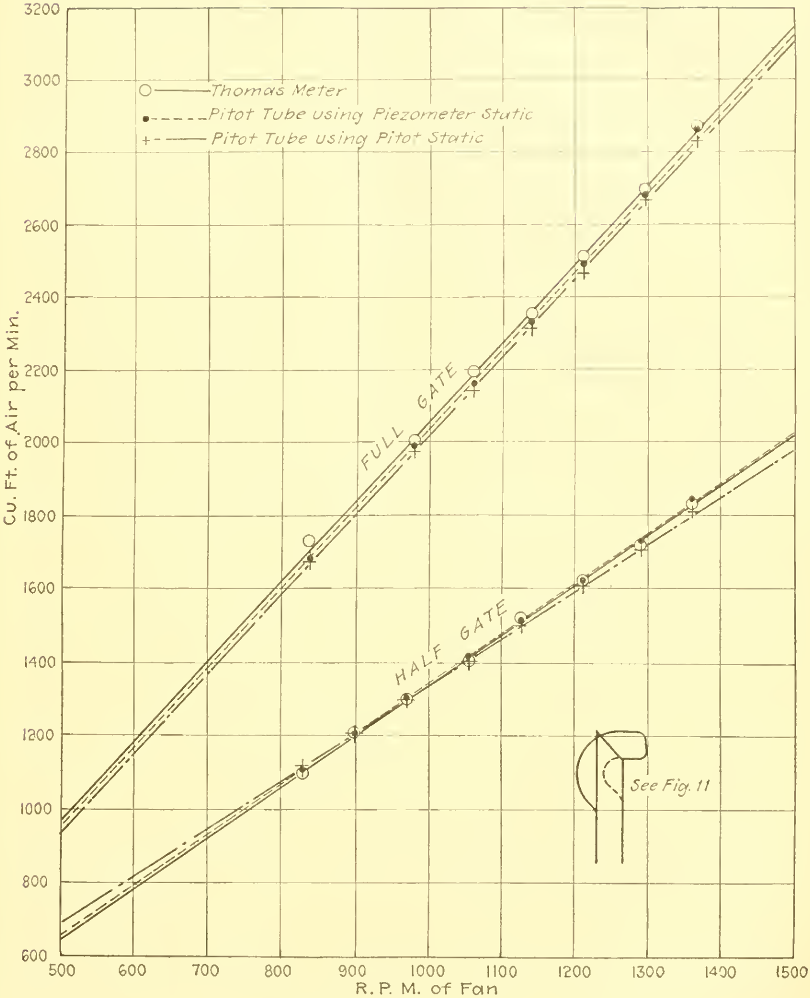
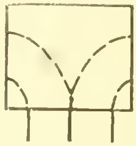


FIG. 24 PITOT TUBE L

TABLE 15 RESULTS OF STAUSCHEIBE *S*



Test No.	R.p.m. of Fan	Cu. Ft. of Air per Min. Thomas Meter C_1	Stauscheibe Using Stauscheibe Static Constant—0.854 C_2	Stauscheibe Using Piezometer Static C_3	*M* $\frac{C_1}{C_2}$	*N* $\frac{C_1}{C_3}$	*O* $\frac{C_3}{C_2}$	*U* $\frac{\text{Col. 18}}{\text{Col. 20}}$	*Z* $\frac{\text{Col. 19}}{\text{Col. 21}}$
26	27	28	29	30	31	32	33	34	35
S–1–F	....	....	....	....	.....	.....	.....	.....	.....
S–2–F	841	1695	1730	1678	0.981	1.009	0.971	0.773	0.807
S–3–F	912	1858	1900	1832	0.979	1.013	0.965	0.779	0.805
S–4–F	983	2003	2060	1986	0.974	1.008	0.965	0.774	0.797
S–5–F	1070	2190	2245	2182	0.976	1.003	0.974	0.778	0.812
S–6–F	1152	2355	2420	2353	0.975	1.001	0.973	0.782	0.809
S–7–F	1220	2555	2590	2522	0.986	1.012	0.975	0.790	0.820
S–8–F	1312	2740	2800	2722	0.980	1.005	0.973	0.797	0.823
S–9–F	1400	2937	2990	2900	0.982	1.012	0.970	0.808	0.823
Average..	....	....	....	....	0.9791	1.0079	0.9708	0.7851	0.8245
S–1–½	....	....	....	....	.....	.....	.....	.....	.....
S–2–½	841	1093	1120	1092	0.978	1.001	0.978	0.772	0.788
S–3–½	918	1214	1223	1208	0.995	1.004	0.990	0.785	0.831
S–4–½	997	1320	1311	1320	1.005	1.000	1.005	0.767	0.840
S–5–½	1074	1417	1427	1423	0.993	0.997	0.997	0.777	0.832
S–6–½	1152	1505	1520	1520	0.992	0.991	1.000	0.772	0.824
S–7–½	1232	1629	1621	1625	1.003	1.002	1.002	0.770	0.817
S–8–½	1314	1720	1743	1750	0.988	0.985	1.004	0.768	0.815
S–9–½	1399	1843	1860	1877	0.990	0.982	1.008	0.772	0.821
Average..........		....	....	....	0.9930	0.9952	0.9980	0.7729	0.8210
Net Average......		....	....	....	0.9861	1.0016	0.9844	0.7780	0.8228

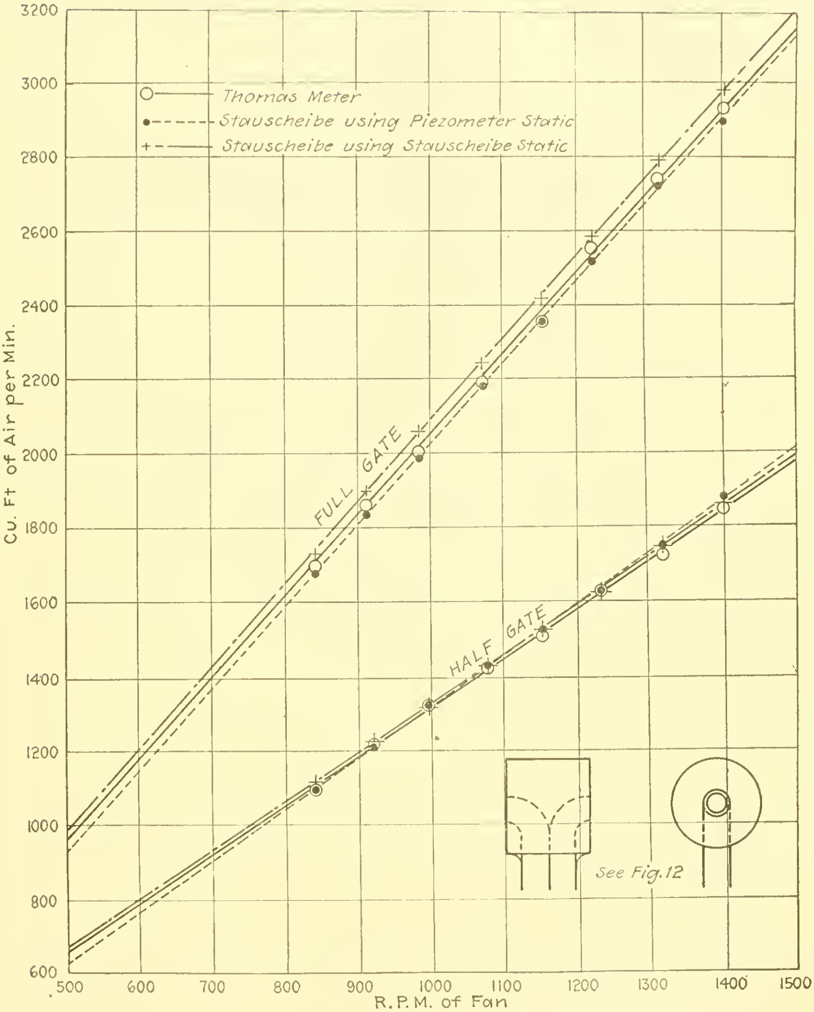


Fig. 25 Stauscheibe *S*

APPENDIX NO. 1

THE ACCURACY OF THE THOMAS METER

48 The Thomas meter has been thoroughly tested under various conditions of service and a few of the tests are briefly referred to in the following notes in order to show that it is a reliable and accurate means for measuring gases and that its use as a standard meter in these experiments with pitot tubes was justified.

TESTS AGAINST CALIBRATED PITOT TUBES [1]

49 A Thomas meter was tested by the People's Natural Gas Company of Pittsburgh at their Brave Pumping Station, in a 10-in. suction line from the gas wells to the pump and in series with a pitot tube station. This latter was located a mile and a half from the pumping station where the electric meter was installed and every precaution was taken to prevent leakage in the intervening pipe line. This pitot tube station was developed after years of experiment and at great expense. The pitot tubes in the station were carefully calibrated under working conditions and were known to give accurate results when the calibration constants were used.

50 A 45-day test was run, from April 7 to June 3, 1911, during which period the rate of flow varied from 90,000 to 640,000 cu. ft. per hour, the pressure of the gas varied from 46 to 185 lb. gage and the temperature varied from 45 to 65 deg. fahr. The results were as follows:

Total standard cu. ft. of gas by pitot tube	337,546,182
Total standard cu. ft. of gas by Thomas meter	336,732,018
Difference	814,164
Per cent of difference	0.24

A year later a test of the same meter was made without any changes of adjustment whatever and the Thomas meter was found to agree with the pitot tubes within 0.42 per cent.

TESTS AGAINST HOLDERS [1]

51 A Thomas meter is used to measure the gas in the common discharge line from the booster station of the Milwaukee Gas Light Company. The holder tests were made with the greatest care on October 13 and 14, 1911, at a time when the temperature had remained constant during the day and night for several days. Two different holders were used. One test was made at the maximum capacity of the meter when the gas was being pumped from the large holder through the meter at a pressure of about 40 in. of water. A second test was made at the minimum capacity of the

[1] Carl C. Thomas. Proc. Am. Gas Inst., vol. 7, 1912.

meter when gas was flowing from the smaller holder through the meter at holder pressure.

52 The results were as follows:

Holder used	Larger	Smaller
Duration of test	2 hr. 15 min.	5 hr.
Total cu. ft. of air by Thomas meter at 30 in. mercury and 60 deg. fahr.	1,956,000	497,500
Total cu. ft. of air by holder at 30 in. mercury and 60 deg. fahr.	1,958,691	498,628
Difference	2,691	1,128
Per cent of difference	0.137	0.224

TESTS AGAINST WET METERS[1]

53 A Thomas meter was imported into Germany to be used in some scientific investigations of blowers and compressors. It was tested against a carefully calibrated wet meter at the Berlin IV Precinct Gas Works under the direct supervision of their engineers, who are of recognized technical ability and who exercised the most painstaking care throughout the tests. A few representative results of the Berlin tests are given below:

Duration of test, hours	1½	3½	3½
Cubic meters of gas by wet meter at 15.5 deg. cent. and 760	5410	7111	14600
Cubic meters of gas by Thomas meter	5400	7076	14537
Difference	10	35	63
Per cent difference	0.20	0.49	0.46

TESTS AT THE WORKS OF THE CUTLER-HAMMER MANUFACTURING COMPANY

54 Experimental work is constantly being carried on by the manufacturers of the Thomas meter. Two of the most interesting tests conducted there are described here through the courtesy of the Cutler-Hammer Manufacturing Company, as they demonstrate the accuracy of the Thomas meter under varying conditions.

55 *First Test.* Two automatically operated Thomas meters, one of 25,000 cu. ft. per hour capacity and the other of 50,000 cu. ft. per hour capacity, were put in the same pipe line in series. When air was flowing through the pipe it was noted that each meter recorded the same amount of air. By means of an electric heater in the pipe between the two meters the temperature of the air entering the second meter was gradually increased until it was 60 deg. fahr. higher than the temperature of the air entering the first meter. The amounts recorded on each meter were meanwhile carefully watched and it was observed that the readings still remained practically identical.

56 *Second Test.* A manually operated test meter was connected in a *horizontal* position in series with an automatically controlled meter which was in a vertical position, with a right angled bend intervening between them. This arrangement was made purposely to prevent the air passing through the two meters in the same manner. The test meter was manually operated on both 110 and 220 volts direct current and the automatic meter on 220 volts alternating current. The automatic meter had a capacity of 500,000 cu. ft. of free gas per hour. The results at different rates of flow were as follows:

9 per cent of maximum flow, error in automatic meter	+ 0.2 per cent
42 per cent of maximum flow, error in automatic meter	+ 0.2 per cent
81 per cent of maximum flow, error in automatic meter	+ 0.0 per cent

[1] Carl C. Thomas. Proc. Am. Gas Inst., vol. 7, 1912.

APPENDIX NO. 2

DATA AND CALCULATIONS

57 In order to show the manner in which the results of the calculations upon the pitot tubes were tabulated, Tables 16 to 18, applying to tubes *A*, *H* and *X* are here reproduced. The explanation of the calculations is as follows:

58 In column 1, Test Number, the first letter designates the pitot tube; the middle figure, the test in the series arranged according to the fan speed; and the last symbol, *F* or ½, signifies full gate or half gate at the discharge end of the test pipe.

59 Column 2 gives the average revolutions per minute of the fan as obtained by a hand revolution counter.

60 Column 3 shows the barometer reading in inches of mercury.

61 In column 4, the atmospheric pressure in pounds per sq. in. is obtained by multiplying the values in column 3 by the weight of a cu. in. of mercury taken from Chart *F* corresponding to room temperature.

62 Column 5 indicates the pressure in the pipe above atmospheric pressure at the point where the pitot tube was inserted.

63 In column 6, the pressure inside the pipe above the atmospheric pressure is the product of the values given in column 5, the specific gravity of the gasolene and the weight of the water per cu. in. taken from Chart *G* corresponding to room temperature.

64 In column 7, the absolute pressure in lb. per sq. in. on the air flowing through pipe at the pitot tube is the sum of the pressures given in column 4 and column 6.

65 Columns 8, 9 and 10 give the averages of the observed temperatures in deg. fahr.

66 In column 11, the percentage of humidity of the flowing air is obtained from Chart *A* and the temperatures given in columns 9 and 10.

67 In column 12, the weight of air partially saturated with water vapor in lb. per cu. ft. is obtained from Charts *D* and *E*. Knowing the temperature of the air (column 10) and the percentage of humidity (column 11) the weight of a cubic foot of air at 14 lb. per sq. in. pressure may be read from Chart *D*. To this value add the correction obtained from Chart *E* corresponding to the pressures given in column 7 and the temperature in column 10. The sum is the weight of a cubic foot of the mixture.

68 The calculations involved in finding the weight of a cubic foot of air partially saturated with water vapor are outlined in Appendix No. 3 and are based on well-known thermodynamic relations.

69 In column 13, the specific heat of the mixture of air and water vapor in B.t.u. per lb. is obtained from Chart *B* corresponding to the tem-

TABLE 16 TABULATED CALCULATIONS, PITOT TUBE *A*

Test No.	R.p.m. of Fan	Pressures: Barometer: In. of Mercury	Pressures: Barometer: Lb. per Sq. In.	Pressures: Static: In. of Gasolene, Sp. Gr.	Pressures: Static: Lb. per Sq. In.	Pressures: Absolute Lb. per Sq. In.	Temperatures: Room, Deg. Fahr.	Temperatures: Wet Bulb, Deg. Fahr.	Temperatures: Dry Bulb, Deg. Fahr.	Humidity, per cent	Weight of Air, Lb. per Cu. Ft.	Specific Heat of Air B.t.u. per Lb.	Thomas Meter: Calibration Constant, K	Thomas Meter: Amperes Corrected	Thomas Meter: Volts Corrected	Thomas Meter: Cu. Ft. of Air per Min., C_1	Pitot Tube: Velocity Heads: In. Gasolene, Sp. Gr. 0.733: Average Using Pitot Static, H_1	Average Using Piezometer Static, H_2	Center Using Pitot Static, H_3	Center Using Piezometer Static, H_4	Ft. of Air: Average Using Pitot Static, h_1	Average Using Piezometer Static, h_2	Cu. Ft. of Air per Min.: Using Pitot Static C_2	Using Piezometer Static, C_3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A-1-½	794	29.200	14.267	1.17	0.031	14.298	80.0	69.8	84.0	48.5	0.07049	0.2445	0.02835	12.49	52.7	1080	0.1336	0.1434	0.1725	0.1765	7.22	7.75	1030	1068
A-2-½	875	29.206	14 270	1.37	0.036	14.307	81.5	70.9	85.1	49.0	0.07036	0.2446	0.02839	12.98	55.15	1178	0.1629	0.1723	0.2110	0.2170	8.82	9.34	1138	1171
A-3-½	951	29 210	14.272	1.41	0.037	14.309	82.2	71.4	86.3	48.5	0.07021	0.2446	0.02843	13.73	57.8	1315	0.1928	0.2060	0.2500	0.2650	10.47	11.18	1240	1280
A-4-½	1028	29.210	14.272	1 69	0.045	14.317	83.1	71.8	87.1	48.0	0.07013	0.2447	0.02848	14.33	60.05	1420	0.2355	0.2450	0.2970	0.3095	12.80	13.32	1371	1399
A-5-½	1107	29.212	14.273	1.96	0.052	14.325	84.0	72.9	88.4	48.0	0.06999	0.2448	0.02853	14.88	62.75	1552	0.2645	0.2860	0.3520	0.3670	14.40	15.57	1452	1510
A-6-½	1190	29.212	14.273	2.28	0.060	14.333	85.7	74.2	90.7	46.5	0.06969	0.2450	0.02865	15.43	64.75	1673	0.3087	0.3440	0.3980	0.4245	16 88	18.81	1573	1662
A-7-½	1266	29.210	14.272	2.60	0.069	14.341	86.8	74.8	91.7	46.0	0.06961	0.2451	0.02871	15.99	67.05	1803	0.3447	0.3893	0.4510	0.4880	18.87	21.31	1663	1770
A-8-½	1371	29.210	14.272	3.00	0.079	14.351	87.8	75.0	93.1	43.5	0.06949	0.2452	0.02878	16.49	69.75	1942	0.3956	0.4495	0.5150	0.5585	21.68	24.65	1782	1902
A-9-½	1447	29.208	14.271	3.38	0.089	14.361	88.5	75.2	94.0	41.5	0.06945	0.2452	0.02883	16.99	71.20	2049	0.4450	0.5122	0.5860	0.6360	24.40	28.10	1892	2030
A-1-F	795	29.142	14.239	0.18	0.005	14.244	86.0	77.2	89.2	58.0	0.06933	0.2456	0.02860	15.52	65.7	1710	0.3392	0.3508	0.4380	0.4440	18.64	19.28	1655	1680
A-2-F	870	29.150	14.243	0.22	0.006	14.249	86.5	76.9	89.8	56.0	0.06928	0.2455	0.02862	16.37	69.4	1910	0.4135	0.4335	0.5405	0.5505	22.74	23.85	1828	1870
A-3-F	947	29.148	14.242	0.27	0.007	14.249	87.0	77.1	90.5	54.5	0.06923	0.2455	0.02865	17.07	72 6	2085	0.4935	0.5235	0.6430	0.6635	27.15	28.80	1995	2058
A-4-F	1031	29.150	14.243	0.32	0.008	14.251	88.0	77.2	91.2	53.5	0.06912	0.2456	0.02870	17.72	75.7	2265	0.5780	0.6180	0.7520	0.7880	31.85	34.06	2160	2237
A-5-F	1118	29.148	14.242	0.37	0.010	14.252	88.8	78.0	92.8	52.0	0.06890	0.2457	0.02877	18.67	79.5	2487	0.6770	0.7365	0.8810	0.9310	37.43	40.73	2340	2440
A-6-F	1191	29.148	14.242	0.41	0.011	14.253	89.7	78.5	93.4	51.5	0.06882	0.2458	0.02879	19.22	81.9	2675	0.7780	0.8480	1.0040	1.0695	43.05	46.93	2513	2620
A-7-F	1273	29.150	14.243	0.46	0.012	14.255	90.0	78.9	94.3	51.0	0.06872	0.2459	0.02885	19.97	84.6	2885	0.8865	0.9685	1.1465	1.2290	49.16	53.65	2685	2805
A-8-F	1370	29.148	14.243	0.54	0.014	14.256	90.0	79.0	94.8	50.0	0.06867	0.2459	0.02887	20.67	87.4	3095	1.0220	1.1110	1.3100	1.4135	56.70	61.65	2880	3005
A-9-F	1458	29.130	14 233	0.62	0.016	14.249	91.0	79.6	96.3	48.5	0.06847	0.2458	0.02893	21.27	90.2	3300	1.1640	1.2815	1.4790	1.6070	64 75	71.30	3080	3240

peratures given in column 10 and the percentage of humidity given in column 11. The method of calculating specific heat of a mixture of air and water vapor for any temperature, pressure and per cent humidity is shown in Appendix No. 3.

70 In column 14, the value of K depends upon the calibration of the resistance thermometers in the Thomas meter and is taken from the curve

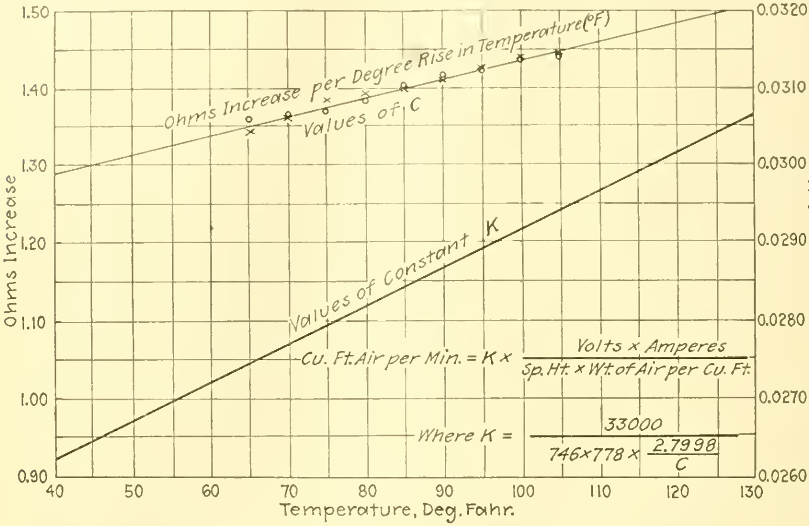


FIG. 26 CALIBRATION OF RESISTANCE THERMOMETERS IN THOMAS ELECTRIC METER

given in Fig. 26. It is defined by its use in the following formula, referred to later under column 17:

$$\text{Cu. ft. of air per minute by the Thomas meter} = K \frac{(\text{volts})\ (\text{amperes})}{(\text{specific heat})\ (\text{wt. air per cu. ft.})}$$

where

$$K = \frac{33000}{746 \times 778 \times \dfrac{2.7998}{C}}$$

See also the description of the Thomas meter in Pars. 13 to 17.

71 Columns 15 and 16 show the corrected readings of the voltmeter and ammeter which measured the electrical energy consumed by the heater in the Thomas meter.

72 In column 17, the cubic feet of air per minute as measured by the Thomas meter is calculated from the following formula:

$$C_1 = K \frac{(V)\ (A)}{S \quad W}$$

where

C_1 = cu. ft. of air per min. as measured by the Thomas meter

TABLE 17 TABULATED CALCULATIONS, PITOT TUBE X

Test No.	R.p.m. of Fan	Pressures: Barometer: In. of Mercury	Pressures: Barometer: Lb. per Sq. In.	Pressures: Static: In. of Gasolene, Sp. Gr.	Pressures: Static: Lb. per Sq. In.	Pressures: Absolute Lb. per Sq. In.	Temperatures: Room, Deg. Fahr.	Temperatures: Wet Bulb, Deg. Fahr.	Temperatures: Dry Bulb, Deg. Fahr.	Humidity, per Cent	Weight of Air, Lb. per Cu. Ft.	Specific Heat of Air B.t.u. per Lb.	Thomas Meter: Calibration Constant, K	Thomas Meter: Amperes Corrected	Thomas Meter: Volts Corrected	Thomas Meter: Cu. Ft. of Air per Min., C_1	Pitot Tube: Velocity Heads: In. Gasolene, Sp.Gr. 0.740–43: Average Using Pitot Static, H_1	Average Using Piezometer Static, H_2	Center Using Pitot Static, H_3	Center Using Piezometer Static, H_4	Ft. of Air: Average Using Pitot Static, h_1	Average Using Piezometer Static, h_2	Cu. Ft. of Air per Min.: Using Pitot Static C_2	Using Piezometer Static, C_3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
X–1–½	785	29.100	14.200	0.90	0.024	14.224	95.0	83.0	98.5	52.5	0.06792	0.2465	0.02905	11.94	50.51	1047	0.1102	0.1293	0.1495	0.1685	6.25	7.33	958	1037
X–2–½	876	29.078	14.185	1.12	0.030	14.215	95.8	81.8	99.0	48.0	0.06788	0.2463	0.02907	12.51	53.32	1161	0.1348	0.1596	0.1795	0.2025	7.66	9.07	1060	1153
X–3–½	954	29.058	14.177	1.35	0.036	14.213	96.0	81.5	99.0	47.5	0.06787	0.2462	0.02907	13.16	55.83	1270	0.1603	0.1901	0.2115	0.2410	9.10	10.80	1156	1260
X–4–½	1028	29.016	14.165	1.60	0.042	14.207	96.0	80.9	99.1	46.0	0.06785	0.2461	0.02908	13.68	57.92	1378	0.1896	0.2287	0.2510	0.2940	10.75	12.98	1256	1380
X–5–½	1120	29.028	14.170	1.86	0.049	14.219	95.5	80.9	99.7	44.0	0.06785	0.2461	0.02911	14.23	60.02	1490	0.2230	0.2659	0.2950	0.3460	12.66	15.08	1363	1488
X–6–½	1195	29.054	14.177	2.16	0.057	14.234	96.0	81.6	100.6	44.5	0.06780	0.2462	0.02915	14.73	62.05	1595	0.2548	0.3106	0.3360	0.3930	14.46	17.63	1457	1609
X–7–½	1288	29.066	14.180	2.55	0.068	14.248	96.3	81.8	100.9	44.5	0.06785	0.2463	0.02917	15.23	64.45	1713	0.2918	0.3568	0.3840	0.4570	16.55	20.25	1557	1723
X–8–½	1370	29.066	14.180	2.92	0.077	14.257	96.3	81.8	101.0	44.5	0.06786	0.2463	0.02918	15.79	66.58	1834	0.3354	0.4192	0.4380	0.5305	19.03	23.80	1670	1870
X–9–½	1460	29.070	14.181	3.30	0.088	14.269	96.5	82.0	101.5	44.0	0.06785	0.2463	0.02920	16.31	68.72	1960	0.3792	0.4788	0.4940	0.6035	21.50	27.20	1775	1996
X–1–F	807	29.034	14.173	0.18	0.005	14.178	80.2	73.3	83.6	62.2	0.06977	0.2452	0.02834	15.03	64.55	1605	0.2840	0.3395	0.3565	0.4295	15.55	18.58	1510	1650
X–2–F	888	29.026	14.168	0.22	0.006	14.174	80.5	74.0	84.1	62.2	0.06967	0.2453	0.02835	15.80	68.75	1800	0.3404	0.4142	0.4290	0.5220	18.70	22.72	1655	1825
X–3–F	963	29.015	14.160	0.26	0.007	14.167	81.0	75.0	85.0	63.0	0.06950	0.2453	0.02838	16.64	70.80	1962	0.4049	0.4968	0.5100	0.6240	22.25	27.30	1805	2000
X–4–F	1046	29.014	14.160	0.31	0.008	14.168	81.5	75.4	85.7	63.0	0.06940	0.2454	0.02842	17.35	73.82	2140	0.4875	0.5874	0.6155	0.7455	26.65	32.35	1975	2180
X–5–F	1135	29.017	14.161	0.38	0.010	14.171	82.0	76.0	86.2	63.0	0.06935	0.2455	0.02845	18.15	77.38	2345	0.5585	0.7014	0.7270	0.8840	30.75	38.60	2125	2380
X–6–F	1229	29.015	14.160	0.40	0.011	14.171	82.5	76.2	86.9	62.7	0.06926	0.2456	0.02848	18.96	80.20	2545	0.6433	0.8124	0.8320	1.0250	35.50	44.80	2280	2562
X–7–F	1311	29.007	14.156	0.47	0.013	14.169	83.3	76.7	88.0	60.5	0.06912	0.2457	0.02853	19.65	83.27	2745	0.7451	0.9279	0.9650	1.1920	41.20	51.25	2455	2740
X–8–F	1410	29.006	14.155	0.52	0.014	14.169	84.0	77.3	89.0	59.5	0.06897	0.2457	0.02857	20.32	85.90	2940	0.8496	1.0863	1.0900	1.3590	47.05	60.20	2625	2970
X–9–F	1496	29.004	14.154	0.60	0.016	14.170	84.8	78.0	90.1	58.5	0.06885	0.2458	0.02862	21.01	88.70	3145	0.9560	1.2331	1.2290	1.5430	53.00	68.45	2785	3165

$(V)(A)$ = volts (column 15) times amperes (column 16) = watts consumed by electrical heater in the Thomas meter

S = specific heat of the air flowing (column 13)

W = weight of the air flowing in lb. per cu. ft. (column 12)

K is taken from column 14

73 Column 18 gives the mean velocity head as measured by the pitot tube using the pitot tube static pressure. It was obtained as follows: Readings were taken of the velocity head at 20 points on the cross-section of the pipe as described in Par. 21 and by Fig. 6. The square roots of these 20 readings were averaged and the square of this average is the value entered in column 18.

74 Column 19 indicates the mean velocity head as measured by the pitot dynamic tube and the piezometer static pressure. It was obtained in the manner described above for column 18.

75 Columns 20 and 21 record the velocity heads when the pitot tube is at the center of the pipe, column 20 using the pitot tube static pressure and column 21 using the piezometer static pressure.

76 Columns 22 and 23 are the velocity heads given in columns 18 and 19 reduced to feet of air flowing. They were calculated as follows:

$$h = 144\ spH$$

where

h = velocity head in ft. of air

s = specific gravity of gasolene

p = weight of water in pounds per cu. in., taken from Chart G

H = velocity head in in. of gasolene as given in columns 18 or 19

77 Column 24 gives the cubic feet of air per minute as measured by the pitot tube using the pitot tube static pressure.

78 Column 25 gives the cubic feet of air per minute as measured by the pitot dynamic tube and the piezometer static pressure.

79 The method of calculating the results given in columns 24 and 25 is as follows:

$$\text{for pitot tube } C_2 = 60\ A\ \sqrt{2gh_1} = 383\ \sqrt{h_1}$$

$$\text{for Stauscheibe } C_2 = 60\ A\ \frac{\sqrt{2gh_1}}{1.17} = 327\ \sqrt{2gh_1}$$

$$\text{for both } C_3 = 60\ A\ \sqrt{2gh_2} = 383\ \sqrt{h_2}$$

where

C_2 = cu. ft. of air per minute as measured by pitot tube using pitot tube static pressure

C_3 = cu. ft. of air per minute as measured by pitot dynamic tube and piezometer static pressure

A = area of cross-section of pipe where pitot tube was inserted = 0.7959 sq. ft.

g = 32.2

h_1 = velocity head in ft. of air taken from column 22 and described previously

h_2 = velocity head in ft. of air taken from column 23 and described previously

TABLE 18 TABULATED CALCULATIONS, PITOT TUBE *H*

	Pressures					Temperatures						Thomas Meter				Pitot Tube							
		Barometer		Static												Velocity Heads						Cu. Ft. of Air per Min.	
																In. Gasolene, Sp. Gr. 0.745				Ft. of Air			
Test No.	R.p.m. of Fan	In. of Mercury	Lb. per Sq. In.	In. of Gasolene, Sp. Gr.	Lb. per Sq. In.	Absolute Lb. per Sq. In.	Room, Deg. Fahr.	Wet Bulb, Deg. Fahr.	Dry Bulb, Deg. Fahr.	Humidity, per Cent	Weight of Air, Lb. per Cu. Ft.	Specific Heat of Air B.t.u. per Lb.	Calibration Constant, K	Amperes Corrected	Volts Corrected	Cu. Ft. of Air per Min., C_1	Average Using Pitot Static, H_1	Average Using Piezometer Static, H_2	Center Using Pitot Static, H_3	Center Using Piezometer Static, H_4	Average Using Pitot Static, h_1	Average Using Piezometer Static, h_2	Using Pitot Static C_2	Using Piezometer Static, C_3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H-1-½	....	......	......	.....	.....	......	....	....	....	....	......	......	......	.....	.....	....	......	......	......	......	.....	.....	....	....
H-2-½	870	29.182	14.270	1.22	0.032	14.302	73.5	63.0	79.0	40.5	0.07129	0.2437	0.02808	13.33	55.93	1203	0.1718	0.1737	0.2180	0.2190	9.33	9.43	1170	1176
H-3-½	948	29.182	14.270	1.46	0.039	14.309	73.5	63.8	80.2	40.0	0.07127	0.2438	0.02814	13.91	58.28	1313	0.2039	0.2067	0.2630	0.2650	11.05	11.22	1274	1284
H-4-½	1029	29.182	14.270	1.70	0.045	14.315	76.0	65.3	82.1	40.0	0.07092	0.2439	0.02824	14.46	60.42	1425	0.2410	0.2459	0.3065	0.3125	13.14	13.40	1390	1403
H-5-½	1110	29.182	14.270	2.05	0.054	14.324	77.5	66.0	83.3	39.5	0.07080	0.2439	0.02830	15.20	63.15	1570	0.2900	0.2943	0.3610	0.3720	15.80	16.05	1523	1535
H-6-½	1185	29.182	14.270	2.34	0.062	14.332	78.9	66.8	84.6	39.0	0.07066	0.2440	0.02836	15.66	65.52	1685	0.3284	0.3407	0.4155	0.4280	17.97	18.62	1623	1654
H-7-½	1265	29.184	14.270	2.72	0.072	14.342	79.9	67.8	85.9	39.0	0.07052	0.2441	0.02844	16.15	67.42	1793	0.3774	0.3879	0.4745	0.4900	20.62	21.20	1738	1763
H-8-½	1360	29.186	14.270	3.08	0.082	14.352	81.5	69.5	88.0	39.0	0.07027	0.2443	0.02853	16.71	69.87	1932	0.4330	0.4516	0.5440	0.5640	23.80	24.79	1870	1910
H-9-½	1454	29.186	14.270	3.51	0.093	14.363	82.5	70.2	89.4	38.5	0.07013	0.2444	0.02860	17.24	72.15	2072	0.4881	0.5153	0.6200	0.6480	26.90	28.43	1986	2040
H-1-F	....	......	......	.....	.....	......	....	....	....	....	......	......	......	.....	.....	....	......	......	......	......	.....	.....	....	....
H-2-F	872	29.150	14.245	0.230	0.006	14.251	80.0	68.7	83.9	46.5	0.07029	0.2448	0.02833	16.74	70.24	1930	0.4579	0.4541	0.5700	0.5690	25.20	24.95	1922	1912
H-3-F	947	29.162	14.248	0.280	0.007	14.255	81.0	68.7	84.7	44.3	0.07021	0.2448	0.02837	17.47	73.28	2108	0.5592	0.5556	0.6735	0.6725	30.75	30.75	2123	2123
H-4-F	1024	29.168	14.252	0.310	0.008	14.260	82.1	69.2	86.3	42.0	0.07002	0.2449	0.02845	18.23	76.26	2300	0.6391	0.6363	0.8030	0.8055	35.27	35.10	2275	2269
H-5-F	1110	29.168	14.252	0.380	0.010	14.262	83.8	70.8	88.1	39.0	0.06981	0.2448	0.02854	18.96	79.47	2508	0.7500	0.7493	0.9435	0.9465	41.45	41.40	2465	2463
H-6-F	1195	29.168	14.252	0.420	0.011	14.263	84.5	71.3	89.4	41.0	0.06962	0.2449	0.02860	19.70	82.24	2710	0.8670	0.8651	1.0940	1.0950	48.10	48.00	2656	2653
H-7-F	1273	29.168	14.252	0.510	0.013	14.265	85.8	72.3	90.8	41.0	0.06944	0.2453	0.02868	20.37	84.91	2910	0.9958	0.9955	1.2465	1.2490	55.45	55.45	2855	2855
H-8-F	1375	29.170	14.252	0.550	0.015	14.267	86.5	73.2	92.1	40.5	0.06927	0.2454	0.02873	21.02	88.00	3120	1.1498	1.1481	1.4380	1.4370	64.00	63.95	3062	3060
H-9-F	1456	29.168	14.252	0.630	0.017	14.269	87.5	74.0	93.4	40.0	0.06910	0.2455	0.02880	21.71	90.48	3330	1.3028	1.3097	1.6330	1.6300	72.70	73.00	3265	3270

APPENDIX NO. 3

CHARTS SHOWING WEIGHTS PER CUBIC FOOT AND SPECIFIC HEATS OF MIXTURES OF AIR AND WATER VAPOR

As explained in the paper, the accurate comparison of results obtained by the Thomas meter and the pitot tube depends upon the use of correct values of the properties of air. It was therefore necessary to make a thorough study of this subject, the results of which are presented in this appendix. The formulae and values were gathered from various sources and represent the most modern information in regard to mixtures of air and water vapor.

As the calculations involved are long and tedious, the author has devised and constructed charts which are here presented in the hope that they may be of value to others. The charts were originally drawn to a much larger scale on a tracing about 2 ft. wide by 5 ft. long. Blue prints from this tracing may be obtained from the Society for 25 cents each.

OUTLINE OF CALCULATIONS TO ACCOMPANY CHARTS D AND E

P_t = total pressure of mixture $= p_a + xp_w$ in lb. per sq. in.
p_a = pressure of dry air in lb. per sq. in.
p_w = saturated vapor pressure in lb. per sq. in. (Marks and Davis steam tables used).
x = per cent humidity.
t = temperature of air in deg. fahr.
W = weight of cu. ft. of a mixture of air and water vapor at t temperature; P_t pressure; and x per cent humidity
w_a = weight of cu. ft. of dry air at a pressure of $(14.0 - xp_w)$ lb. per sq. in.
w_c = correction to be added to w_a for pressures above 14.0 lb. per sq. in.
w_w = weight of water vapor contained in 1 cu. ft. of saturated air
S = specific heat of a mixture of air and water vapor (B.t.u. per lb.)
S_a = specific heat of dry air $= 0.24112 + 0.000009\ t$ (Harvey N. Davis, Trans. Am. Soc. M. E., vol. 30, p. 750, 1908.)
S_w = specific heat of water vapor $= 0.4423 + 0.00018\ t$ (Willis H. Carrier, Trans. Am. Soc. M. E., vol. 33, p. 1016, 1911.)
R = 53.35
T = $459.6 + t$

For Dry Air:

$$p_a V_a = RT$$

$$w_a = \frac{1}{V_a} = \frac{p_a}{RT}$$

$$W = w_a + xw_w + w_c$$

$$w_a = \frac{(144)\ (14.0 - xp_w)}{(53.35)\ (459.6 + t)}$$

$$w_c = \frac{(144)\ [P_t - 14.0]}{(53.35)\ (459.6 + t)}$$

$$S = \frac{(w_a + w_c)\ (S_a) + (xw_w)\ (S_w)}{w_a + xw_w + w_c}$$

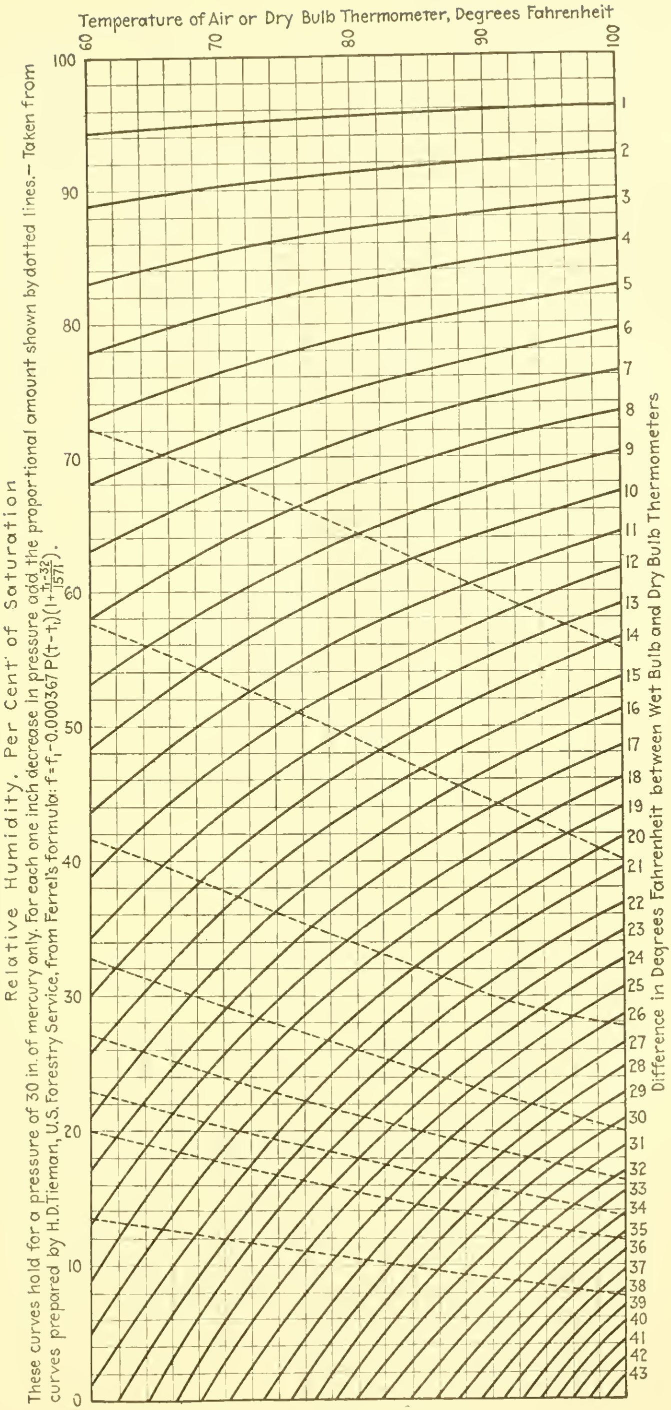


CHART A HUMIDITY CHART

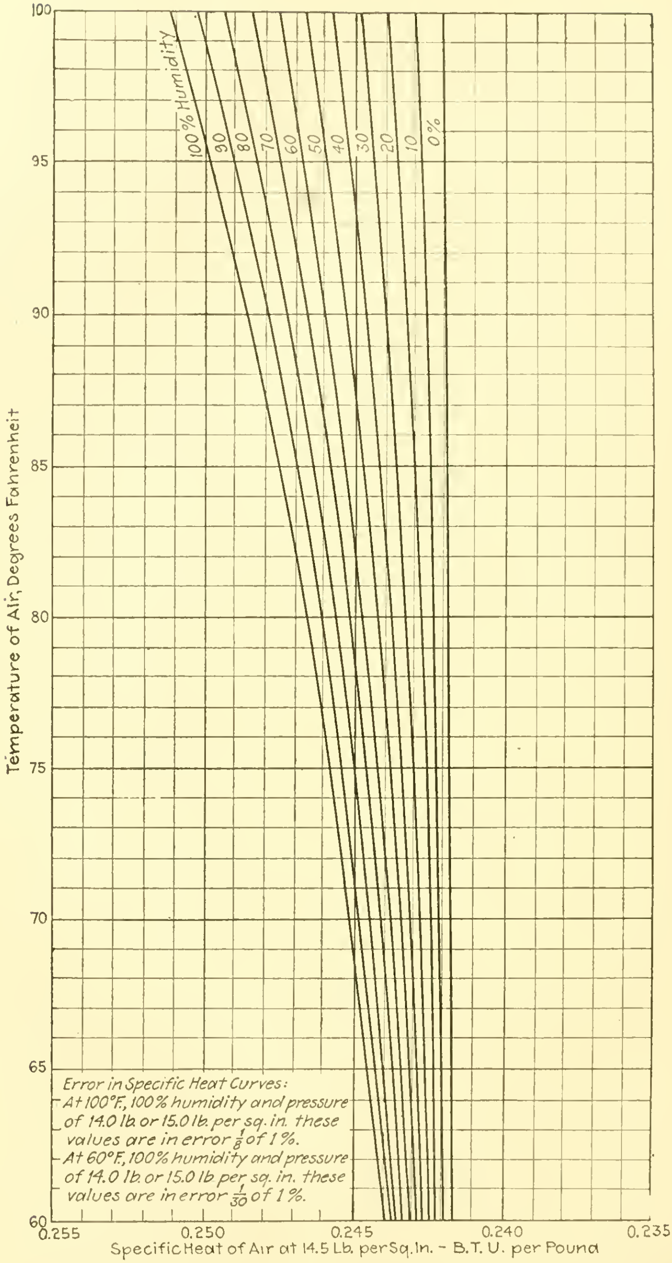


CHART B CHART GIVING THE SPECIFIC HEAT OF MIXTURES OF AIR AND WATER VAPOR AT 14.5 LB. PER SQ. IN. ABSOLUTE PRESSURE FOR VARYING CONDITIONS OF TEMPERATURE AND HUMIDITY

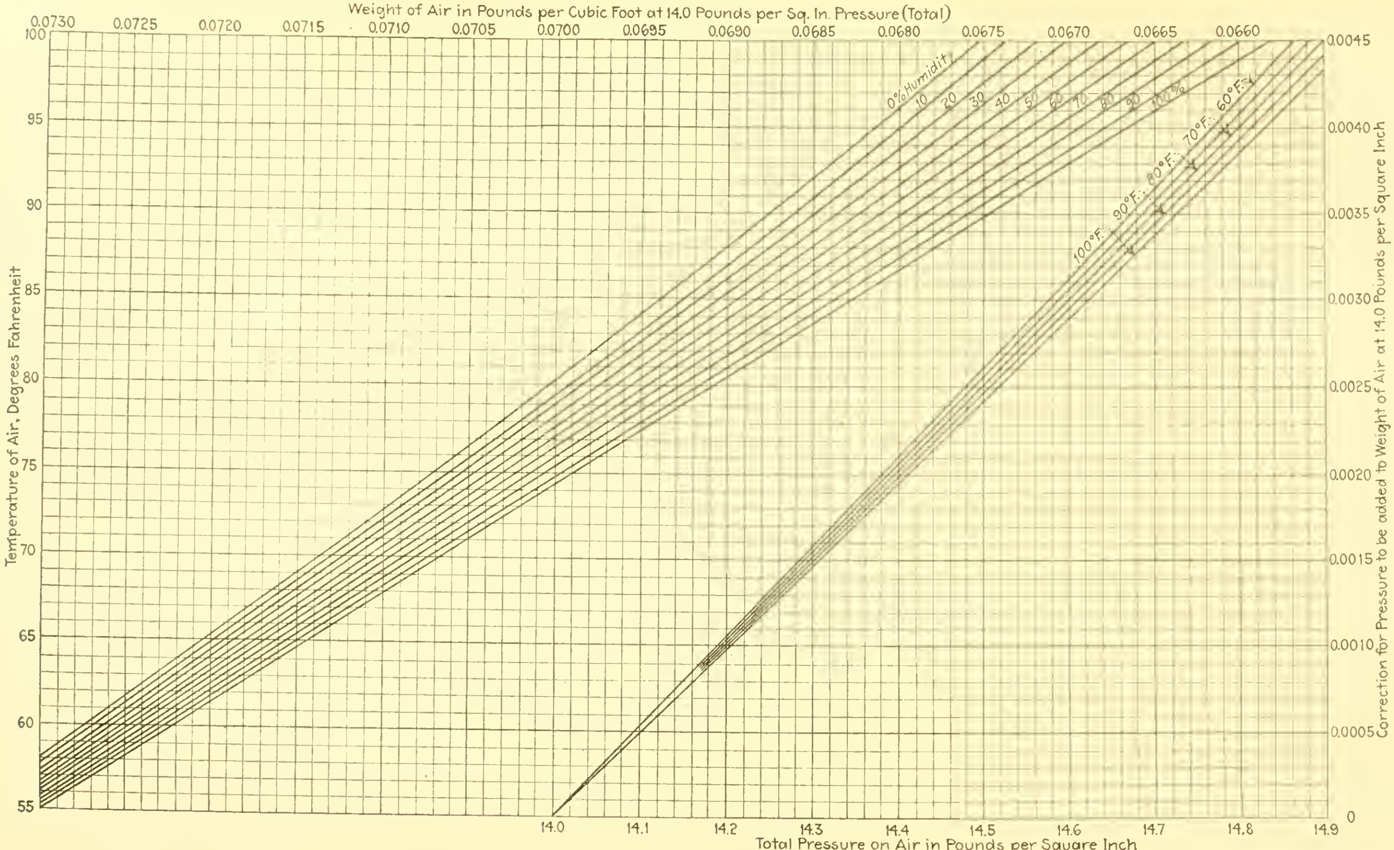


Chart D Chart giving the Weight of Mixtures of Air and Water Vapor at 14.0 Lb. per Sq. In. Absolute Pressure for Varying Conditions of Temperature and Humidity

Chart E Chart giving the Values to be added to the Values Taken from Chart D for Absolute Pressures above 14.0 Lb. per Sq. In.

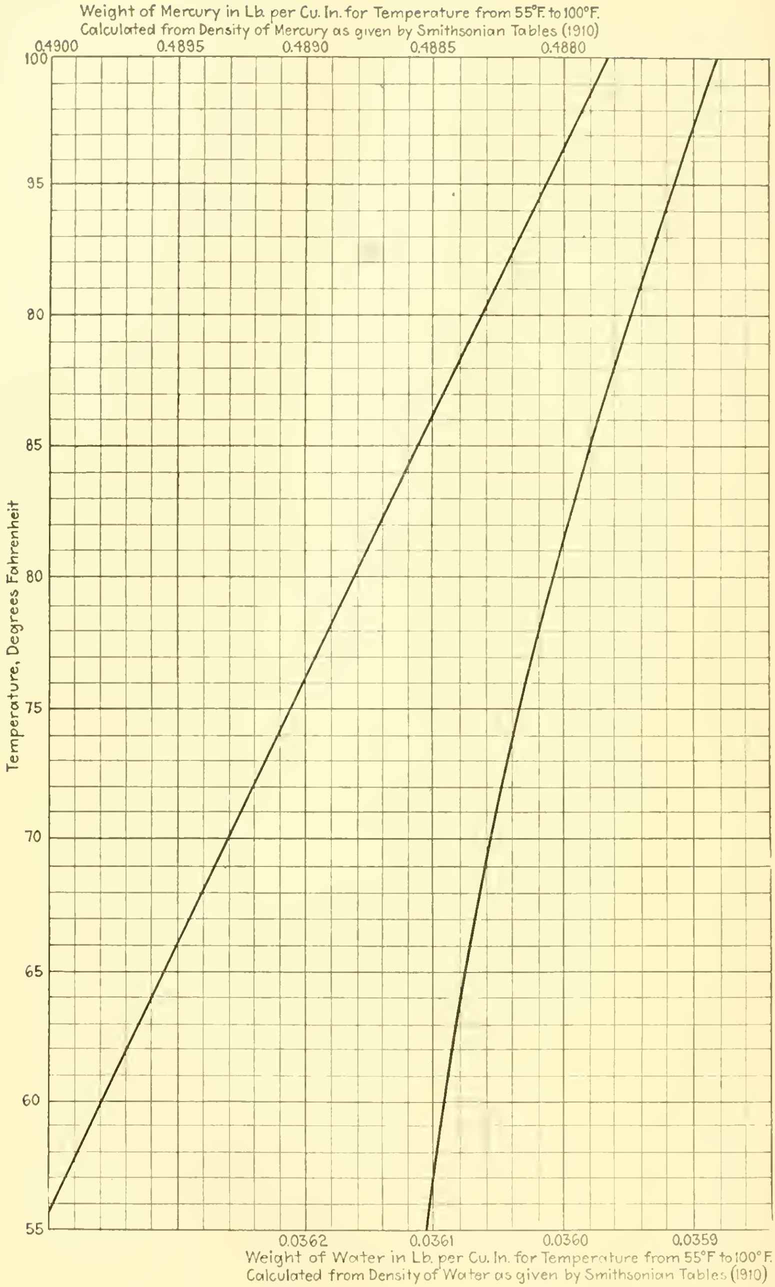


Chart F Weight of Mercury in Pounds per Cubic Inch at Varying Temperatures

Chart G Weight of Water in Pounds per Cubic Inch at Varying Temperatures

TESTS OF VACUUM CLEANING SYSTEMS

By J. R. McColl

ABSTRACT OF PAPER

The paper gives an outline of some tests of vacuum cleaners made for the Board of Education, Detroit, Mich. The tests were divided into two series: (*a*) with the machines on hose and piping as presented or recommended by the manufacturers; and (*b*) with all machines on the same hose and piping system, for the purpose of direct comparison. Each of these series was divided into two parts: (1) tests for ability to do work at the tool end of the hose; (2) analyses of machines as machines.

The paper outlines some of the fundamental principles of vacuum cleaning and contains various curves and tabulated data giving the results of the tests in detail, covering energy developed, power consumption, losses in hose and piping, efficiency, etc.

TESTS OF VACUUM CLEANING SYSTEMS

By J. R. McColl, Detroit, Mich.

Member of the Society

In June 1911, the firm of engineers of which the writer is a member conducted a series of tests on vacuum cleaning systems for the Board of Education of Detroit, Mich., for the purpose of comparing the merits of the various stationary machines for which proposals had been received, to be used in equipping eight school buildings. The specifications provided that the vacuum cleaning system must be of a capacity such as to take care of two sweepers operating simultaneously on a given system of piping, each sweeper to be provided with 75 ft. of hose. The capacity requirement for each sweeper was stipulated as 80 cu. ft. of free air to be handled with a vacuum of 1 in. of mercury inside an orifice at the tool or sweeper end of the hose. These requirements or specifications for volume, vacuum, and equivalent working orifice, at the end of the prescribed hose, any two of which settle the third, represent what was specified as "the ability to do work."

2 The specifications provided that all bidders must submit their machines for two series of tests: *A*, with the piping system and hose as proposed or required by the manufacturer, for the purpose of determining if under these conditions, the machine would give the required volume and vacuum as above outlined; *B*, with an arbitrary hose and piping system which would be the same for all machines, in order to make a direct comparison of the various machines under identical service conditions. The importance of this second series was emphasized by the specifications. Each of the two series of tests was divided into two parts: (1) measuring the "ability to do work" at the tool end of the prescribed hose; (2) analysis of the machine from the standpoints

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

of maintenance and repairs, simplicity, efficiency of lubrication, dust separation and collection, floor space, noise, tools and hose. Separate grades were given to each machine on its ability to do work and on its character as a machine, and these grades were then combined to get the total score.

3 The specifications provided that in grading machines the ability to do work would not count for more than two-thirds of the total score. It was the sense of the committee who assisted that a machine which makes a fine showing in ability to do work and yet has a low score as a machine is as much to be avoided as one which gains a high score as a machine and shows a poor ability to do work. The two features must be considered together in rating a machine. After going over various details involved, the consensus of opinion was that for a school building, 60 points should be given to the machine as a machine and 40 points to its ability to do work. This was of course an arbitrary standard, regarding which there would no doubt be a wide diversity of opinion among engineers, but as long as all machines were scored uniformly in accordance with this assumed standard, it has the stamp of fairness. The 60 points for the machine as a machine, were divided as follows:

Maintenance and repairs	20	
Simplicity	5	
Lubrication	5	
Dust collection	5	
Space	5	
Noise	5	
Tools and hose	15	60
Ability to do work		40
		100

4 Regarding the possible question that may arise in the tests of Series *A* where the machines were not operating under similar conditions as to hose and piping, whether any scores should have been given, on the grounds that it is unfair to grade the results of a machine using a large hose with the results of one working on a small hose, it should be explained that the distinction between the two series of tests is as follows: in the first series, the hose and piping system as proposed was considered an integral part of the machine, inseparable from it; in Series *B* the hose and piping were treated as auxiliary to the machine and independent of it. The scores of Series *A* represent simply

the results obtained from the various machines as presented, though working under dissimilar conditions. The scores of Series *B* represent the comparative merits of the machines when put on the same hose and piping and working under the same conditions.

5 The total grades for the various machines made up from the results of the tests as to the ability to do work, combined with the rating of the machines as machines, are given in column 6, Table 1. The method of computation for that part of the grade covering the ability to do work was made up on the basis of 40 points for meeting full specification requirements of 80 cu. ft. of air per sweeper, with 1-in. vacuum inside the equivalent working orifice. Machines which exceeded this capacity were scored proportionally above 40; and those falling below this capacity were correspondingly debited. It is evident, therefore, that the total score is made up of the sum of the various scores covering the machine as a machine on the basis of 60 points, combined with its ability to do work on the basis of 40 points, when just fulfilling specified requirements. The scores are therefore not percentages, but measures of standing on a reasonable, though arbitrary, scale. The percentages basis could have been used, had no extra credit been given to machines exceeding the specified requirements, or if the capacity attainments of the highest machine were taken as the basis of 40 points and others graded accordingly, but the method used was simpler and equally fair.

6 It was outlined in the specifications that the piping system used as a basis to work from would be a 2-in. line for the inlet system and a 2½-in. for the exhaust system, but manufacturers were permitted to specify other sizes for the first series of tests as a proposed part of their equipment, if so desired or required. This piping system was furnished and installed by the Board of Education. One manufacturer, bidding on the fan type of machine, was permitted to install a 3-in. piping system for use with his machine. Series *B* of the tests included runs made for all high-vacuum machines on the 2-in. piping system, as well as for all machines on a 3-in. piping system, under identical conditions as to hose. It was the writer's expectation to make the comparative series of tests, outlined as Series *B*, with all machines on the largest piping system and the largest hose required or specified by any manufacturer, but he was unable to carry out the plan as regards the hose, and the 1¼-in. hose of the Board of Education was used for all comparative tests.

TABLE 1 RESULTS OF TESTS

1	2	3	4	5	6	7	8	9	10	11	12			
Designating Letter	Type of Machine	No. of Sweeper	Size of Piping. In.	Size of Hose, In.	Score	Electric Current Consumption in Kw-Hr.		Cu. Ft. Free Air for 1 In. Vacuum Inside Orifice	Vacuum at Machine for 80 Cu. Ft. Free Air per Minute per Hose	Apparent Displacement at Machine for 80 Cu. Ft. Free Air	Pull to Move Following Lengths of Hose on Floor in Lb.			
						For Column 9	For 80 cf. Fr. Air				75 Ft.	37½ Ft.	25 Ft.	12½ Ft.
		As proposed—one-sweeper capacity												
F_1	Rotary Exhauster......	1	2	1½	93.4	2.72	3.23	86.6 2nd test	7.13	106.0	18.25	8.25	5.5	3.0
D_1	Multi-Stage Fan.......	1	3	1½	93.2	1.85	1.76	90.5	3.75	92.0	22.5	9.5	7.0	3.5
G_1	Single-Stage Fan.......	1	3	25′=2¼″+50′=1¾	85.6	1.62	....	61.5	....	....	22.0	7.0	4.5	2.5
F_1	Rotary Exhauster......	1	2	1¼	84.0	2.15	....	67.3 1st test	....	....	13.0	5.5	4.75	2.5
C_1	Rotary Exhauster......	1	2	1¼	82.0	2.5	2.5	82.0	76.2	108.5	19.5	9.0	4.75	2.5
		As proposed—two-sweeper capacity												
G_2	Single-Stage Fan.......	2	3	50′=2½″+25′=1¾	97.6	1.95	.95	177.8	2.07	86 0	22.0	7.0	4.5	2.5
F_2	Rotary Exhauster......	2	2	1½	85.5	3.95	....	142.0 2nd test	....	....	18.25	8.25	5.5	3.0
B_2	Rotary Exhauster......	2	2	1¼	83.0	9.25	4.22	175.5 2nd test	9.87	121.0				
F_2	Rotary Exhauster......	2	2	1¼	78.7	3.99	....	115.3 1st test	....	....	13.0	5.5	4.75	2.5
B_2	Rotary Exhauster......	2	2	1	66.0	10.8	....	93.8 1st test	....	....	23.0	10.75	5.5	4.0
E_2	Reciprocating, Plunger.	2	2	1¼	57.7	11.5	5.37	169.0	9.55	118.8	19.5	9.0	4.75	2.5
A_2	Reciprocating, Plunger.	2	2	1	35.4	6.7	....	97.1	....	....	25.0	13.5	8.5	5 25

		Comparison on school board hose—one sweeper								
F_1	Rotary Exhauster......	1	3	1¼	90.3	3.11	3.1	80.8	7.3	107.0
F_1	Rotary Exhauster......	1	2	1¼	88.9	3.27	3.0	78.2	....	....
D_1	Multi-Stage Fan.......	1	3	1¼	86.9	1.65	....	59.0	....	....
C_1	Rotary Exhauster......	1	3	1¼	80.5	2.45	2.5	78.8	7.25	106.5
G_1	Single-Stage Fan.......	1	3	1¼	68.7	0.7	....	28.0	....	....
		Comparison on school board hose—two sweepers								
F_2	Rotary Exhauster......	2	3	1¼	83.9	4.67	....	135.0	....	....
B_2	Rotary Exhauster......	2	2	1¼	83.0	9.25	4.22	175.5	9.87	121.0
F_2	Rotary Exhauster......	2	2	1¼	82.0	4.25	....	128.4	....	....
B_2	Rotary Exhauster......	2	3	1¼	75.3	3.5	....	131.0	....	....
G_2	Single-Stage Fan.......	2	3	1¼	72.3	1.45	....	69.5	....	....
E_2	Reciprocating, Plunger.	2	3	1¼	61.5	12.73	6.5	183.0	10.1	122.5
E_2	Reciprocating, Plunger.	2	2	1¼	57.7	11.45	5.37	168.6	9.55	118.8
A_2	Reciprocating, Plunger.	2	3	1¼	48.5	5.4	....	148.7	....	....
A_2	Reciprocating, Plunger.	2	2	1¼	45.8	5.3	....	139.0	....	....
		3-in. Piping and proposed hose								
F_1	Rotary Exhauster......	1	3	1½	95.3	2.58	3.15	90.8	7.1	105.6
F_2	Rotary Exhauster......	2	3	1½	86.3	3.82	....	146.0	....	....
G_1	Single-Stage Fan.......	1	3	25′ = 2¼″ + 50′ = 1¾	85.6	0.78	....	61.5	....	....
C_1	Rotary Exhauster......	1	3	1¼	80.5	2.45	2.5	78.8	7.25	106.5
A_2	Reciprocating, Plunger.	2	3	1	34.4	6.9	....	94.0	....	....

7 It is obvious that all machines would have given much better results, as regards ability to do work, and lower power consumption, had the comparative tests been made with a larger hose, but in the writer's opinion, as well as that of one or two of the committee who had much to do with air engineering, the general order of standings would not have been very materially changed, judging from the apparent displacements at the machine, as shown in column 12 of Table 1. The exact relative positions and grades, however, could be determined only by the actual tests.

8 Machines were submitted by seven manufacturers, two submitting both single-sweeper and two-sweeper outfits. A variety of machines was represented; there were two fan-type machines, one a single-stage and the other a multi-stage; two reciprocating plunger-type machines; and three of the rotary exhauster or impeller type. It was interesting to note that machines submitted for the same specified duty, ranged in weight from a few hundred pounds to a ton or more. Another interesting feature was that the vacuum at the machine in the effort to accomplish the same specific requirements as to volume at the tool end of the proposed hose, ranged from little more than 2 in. of mercury to approximately 15 in. The power consumption for the same ability to do work ranged from approximately 1¾ kw. to over 13 kw., depending upon the particular type of machine, and especially on the size of the piping and hose used, which ranged in size from 1 in. in diameter to 2½ in. in diameter, the latter size being that at the inlet connection for a hose tapered down from 1¾ in. in diameter at the tool.

9 No uniformity in sizes of hose and tool handles was found among the manufacturers of so-called high-vacuum machines, and low-vacuum machines, and it will doubtless be a long time before they will agree on an exact size of hose and tool handle. These will always be largely matters of personal taste and also matters depending on the importance put by the manufacturer or user, on the question of convenience as contrasted with the importance of the greater ability to do work at a less consumption of power. The larger the hose and tool handle, within reasonable limits, the more rapid and effective work the operator should be able to do with the least consumption of power. But weight of hose and tool handles is often confounded with size. Some of the hose submitted with machines for the tests could have been

much lighter and yet have been strong enough for the maximum vacuum on it. The weight of the hose, for convenience sake, should be as light as possible, consistent with durability and the maximum vacuum desired or required to be carried on it, not only for its new rotund condition, but for its possible flattened condition after months of use.

10 As regards the size of piping, the larger this is, the higher the available vacuum for the hose; if too large, however, the average velocity of the air will not be sufficient to insure the carrying of refuse in horizontal runs, and to prevent clogging. Experience led to the belief that the velocity should not fall much below 2000 ft. per min. in a horizontal run. A tool under ordinary working conditions is handling a varying volume of air. Fortunately at frequent intervals the tool is lifted from the floor or tipped to a marked degree, thereby permitting a comparatively large volume of air to be handled for a brief period at least. If these periods are frequent enough, the volume of air thus intermittently handled will tend to keep the piping system clean, even though the average velocity may be below that already given. Vertical risers should not clog. The factors which operate to limit or prevent the use of large piping are: first cost of installation, the space occupied, the question of cutting into building walls, and the unsightly appearance of large pipes. On the other hand, the enormous wastes due to small hose and piping, so conspicuously brought out in some of the results of the tests, make it desirable to use as large piping as possible, to say nothing of the hose.

11 It seems reasonable to believe that the time will come when the maximum and minimum sizes of hose and piping systems will be standardized for various types of buildings and for various kinds of service, and that these features will be just as distinctly specified as are now the sizes of wires for a given electric service, or as the size of steam pipes and return lines for a given heating service.

METHODS OF TESTING

12 The Capron school in Detroit, one of the buildings to be equipped with a vacuum cleaning system, was used for the tests and all machines were delivered to the basement for this purpose. The 2-in. piping system in the building and the 3-in. piping system already mentioned were arranged so that each machine in

turn could be connected for the various tests, which covered power to drive, ability to do work, vacuum at the machine, speeds, etc.

13 For the work of the committee assisting the author in analyzing the machines as machines, and in grading each according to its merits on the basis of the arbitrary standards given above, each machine was taken into one of the basement rooms, dismantled and critically inspected from the various standpoints already

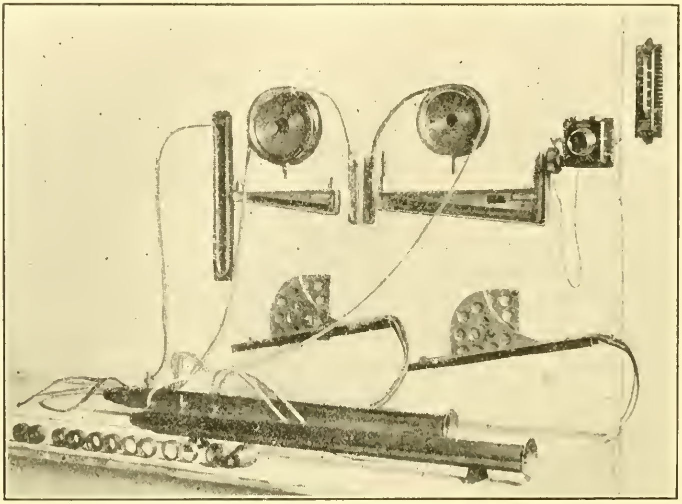


Fig. 1 View of Apparatus for Testing Ability to do Work

outlined. Copious notes were made and the various points fully discussed and considered in the subsequent meeting where the final grades were made up.

14 For the power tests at the machine, the usual readings of speed, current consumption, vacuum, etc., were made, similar to those taken in other lines of tests.

15 The apparatus for measuring the ability to do work at the tool end of the hose was set up in the principal's office on the first floor and two lines of hose 75 ft. in length were carried from inlet connections on the first floor corridor to this room. As already outlined, the end of each hose was restricted by a series of arbitrary orifices, introduced successively, and the vacua with the corresponding volumes of air handled were determined.

16 The apparatus used in these determinations is illustrated in Fig. 1, which is a photograph taken immediately after the tests. The pitot tube method for determining air velocities was used in the measurement of air volumes. The type of pitot tube used was one which the writer and others who have had much to do in recent years with air measurements have found the most accurate. It was similar to the pitot tube described in the paper by Mr. Charles H. Treat.[1] Fig. 2 shows a cross-section of the rectifying barrel or tube, pitot and static tubes, orifice, and orifice holder with vacuum gage connection, etc. The rectifying tube consists of a cylinder with an inside diameter of 2 in. and a length of approximately 36 in. The inlet end is made with a bell-mouth to overcome in some degree the vena contracta effect of the entering air, and to assist in making sure that the air is moving practically in parallel lines when it encounters the pitot tube.

17 The pitot and static tubes were soldered together and made into an L-shaped instrument, pointing up-stream, and the connections for the manometer were separated for easy connection, as shown. The pitot tube leg was placed parallel to the axis of the rectifying barrel. The dimensions and details of this instrument are shown in Fig. 3. It was first intended to make the pitot tube adjustable to any position across the diameter of the rectifying barrel in order to take a series of readings at properly selected points, and average them as outlined in Mr. Treat's paper. This would give more accurate results as to average velocities, but when the multiplicity of readings for the great number of tests to be made and the limited time available were considered, this idea was abandoned. The average of a series of readings for 80 cu. ft. of air per minute was taken and then the pitot tube was set at the point where it gave the average reading when handling this volume of air. When handling other volumes, the pitot tube reading at this fixed position would not be strictly accurate for determining the average velocity.

18 The static tube consisted of a small brass tube soldered to the pitot tube, the up-stream end being sharpened to split the air and cause as little eddying round the instrument as possible. Both pitot and static tubes were made as small as practicable to give as little disturbance as possible in the air currents. But some eddying, of course, is present at best, and to make sure that

[1] Trans. Am.Soc.M.E., vol. 34, p. 1019.

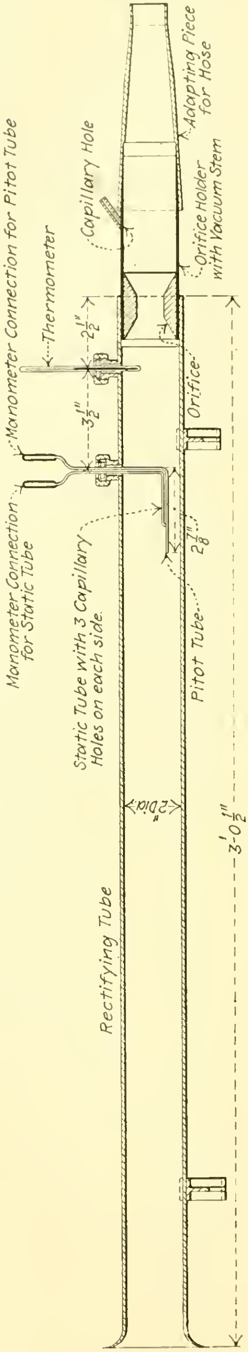


Fig. 2 Section of Pitot Tube Apparatus and Orifice Holder

this should not increase the true static reading, the perforations in the side walls of the static tube were made small capillary holes. Obviously the success of the pitot tube method of air measurement depends, in the first place, on the accuracy with which the pitot and static tubes will separate the pressure which is purely static, from that which is the sum of the static and velocity pressures; and in the second place, on having readings

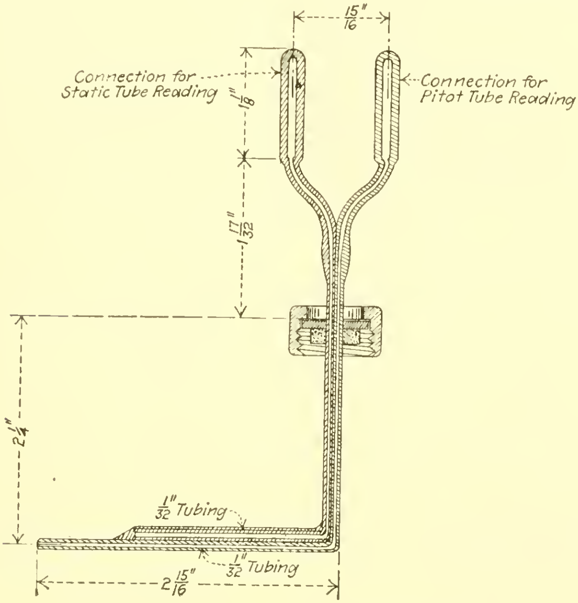


FIG. 3 DETAIL OF PITOT AND STATIC TUBES

taken at correctly established points which will give average velocity readings for the whole transmitting area.

19 No attempt was made in the design of the orifices used in the tests to make them in accordance with any mathematical formulae. These orifices served only the purpose of restricting the tool end of the hose arbitrarily, in order to give a range of readings between the vacuum behind the orifice and the volume of air handled. If vacuum and orifice or volume and orifice were to be specified instead of volume and vacuum, it would be necessary to give the details of the various orifices to be used, inasmuch as the equivalent working area and apparent area may be at wide variance.

20 The inclined manometer with gasolene for liquid was used for determining the difference between total pressure and static pressure or velocity pressure. The manometers are shown in Fig. 1. The angle of inclination for multiplying the reading was taken to suit the velocity pressure developed in order to get as long a reading and as little a percentage of error as possible. Connections to the manometer were reversed and the average taken for each reading so as further to reduce possible errors. The specific gravity of the oil was carefully determined in order that the true value of the velocity head for each reading could be computed. The density of the particular air handled was computed from government tables, taking into account barometric pressure, temperature and humidity, and from these data, for the average velocity readings, actual velocities were then computed.

21 The average velocity in feet per minute multiplied by the cross-sectional area of the 2-in. rectifying tube, expressed in square feet, gave the volume of air handled per minute for each reading. The rectifying barrel was fitted with a thermometer for taking the temperature of the air passing the pitot tube. Ordinary mercury manometers were used for the readings of the vacua behind the orifices, although in some instances standard vacuum gages were connected up for additional readings. The sling psychrometer was used for humidity and temperature determinations. Weather bureau readings were taken for the barometric pressures.

22 Applying the formula $v = \sqrt{2gh}$ to find the volume of air handled, the following equation is deduced

$$CFM = 60A \sqrt{2g \frac{W}{w} \cdot \frac{1}{12} \cdot R \sin\theta} \qquad \text{[1]}$$

where

CFM = cubic feet of free air handled per minute
A = area of rectifying barrel in sq. ft.
g = acceleration due to gravity = 32.2
W = weight of 1 cu. ft. of oil, such as used in manometer
w = weight of 1 cu. ft. of air handled, corrected for barometer, temperature and humidity
R = reading of inclined manometer in in.
θ = angle of inclination of manometer from the horizontal position

23 For the sake of convenience in reducing the apparent reading of the manometer to the true reading, the manometer supporting plate was graduated so that the manometer could be easily set to positions where its scale reading multiplied the vertical reading by 2, 5, 10, and 20, as desired, according to the particular setting used.

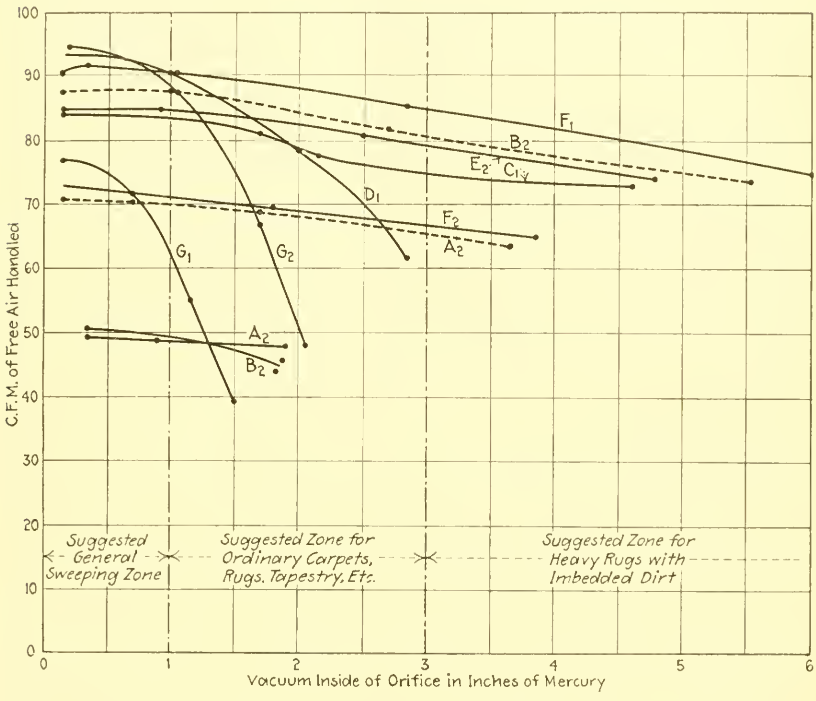


Fig. 4 Curves of Volume and Vacuum at Tool for Piping and Hose as proposed

24 In a given test, all the quantities in equation [1] can be taken constant, with the exception of R, which alone can be left under the radical, thus simplifying the reduction work for the various readings to a minimum. A scale reading directly in cubic feet of air per minute has been used by the writer as sufficiently accurate for commercial tests.

25 The results of the tests covering the ability to do work, power consumption, etc., are given in Table 1. This table gives the designating letter, type of machine, sweeper capacity of each

machine, size of piping and hose used, current consumption and other necessary data including the combined scores made up as outlined. Some of the data given in this table, and other results of the tests, are given in other form by curves, Figs. 4 to 7. Where machines did not handle per hose 80 cu. ft. of free air per minute with a vacuum of 1 in. inside the orifice, the values in columns 8, 10 and 11 are indeterminable.

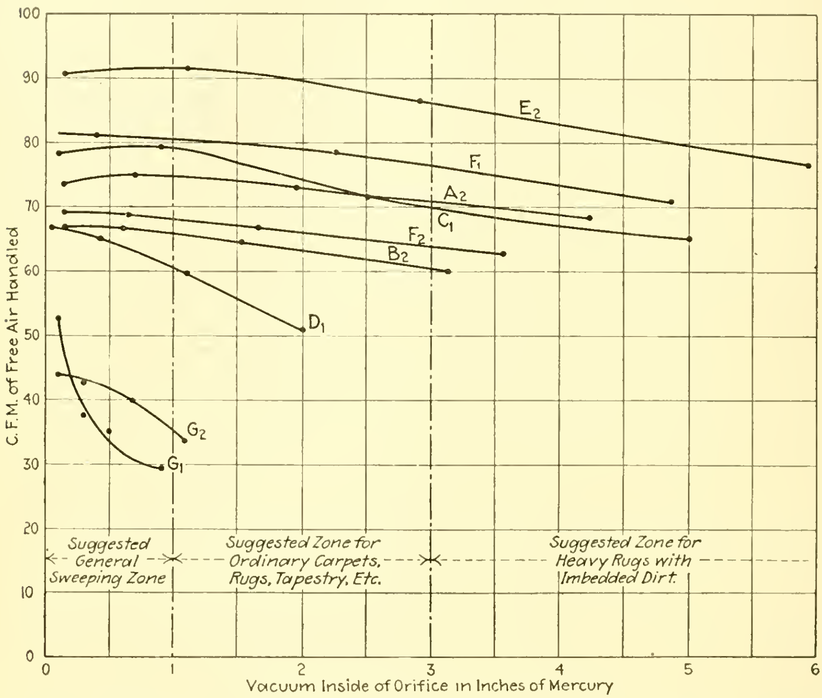


Fig. 5 Curves of Volume and Vacuum at Tool for 3-in. Piping and 1¼-in. Hose; the Same for All Machines

26 Fig. 4 is a series of interesting curves. plotted between cubic feet of free air handled per minute and vacuum inside the orifice at the tool end of the hose for the various machines, operating with the piping and hose system as proposed or required by the manufacturer and designated as Series *A*. The types of machines and sweeper capacities, together with sizes of hose and piping, can be obtained from Table 1.

27 Fig. 5 gives an interesting series of curves plotted between cubic feet of free air handled and vacuum behind the orifice for

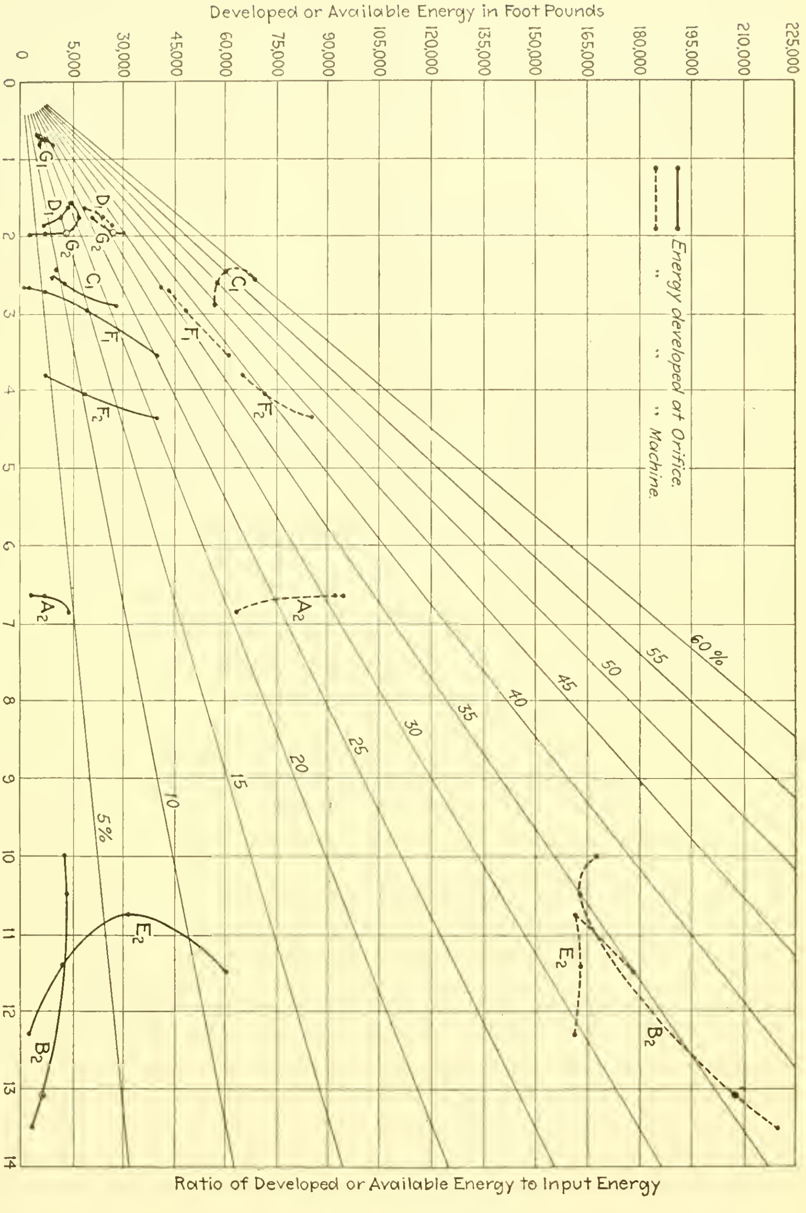


FIG. 6 CURVES, WITH EFFICIENCY LINES, FOR ENERGY DEVELOPED AT MACHINE AND AT TOOL WITH PIPING AND HOSE AS PROPOSED

the various machines operating on the 3-in. piping and 1¼-in. hose; the same for all machines outlined above as Series *B* of the tests.

28 In Figs. 4 and 5 have been drawn zone lines as boundary vacuum lines for effective work in the classes indicated. These are suggestive only, and doubtless would be placed differently by different investigators. It is probable, when vacuum cleaner tests are standardized, that some similar zone boundaries will be established and the qualifications of various machines for different classes of work be thus compared.

29 Without trying to determine whether the expansion of the air through the working orifice or through the piping system is isothermal, adiabatic or something else, the available energy or work developed at the orifice and at the machine end of the piping system for all practical purposes can be expressed in foot-pounds per minute, by the product of the rarified volume per minute and vacuum in pounds per square foot. To express it algebraicly

$$E_1 = 144 \times 0.49 \ (p - p_1) \ v \frac{p}{p_1} = 70.704 m_1 v \frac{p}{p_1} = 70.704 m_1 v_1 . [2]$$

$$E_2 = 144 \times 0.49 \ (p - p_2) \ v \frac{p}{p_2} = 70.704 m_2 v \frac{p}{p_2} = 70.704 m_2 v_2 .. [3]$$

where

E_1 = energy inside of orifice, in ft-lb. per min.
E_2 = energy at machine in ft-lb. per min.
p = barometric pressure of free air in in. of mercury
p_1 = absolute pressure inside of orifice in in. of mercury
p_2 = absolute pressure inside piping system at machine end in in. of mercury
v = volume of free air handled per min. in cu. ft.
v_1 = corresponding volume of air inside of orifice
v_2 = corresponding volume of air at machine
m_1 = vacuum inside of orifice in in. of mercury
m_2 = vacuum at machine in in. of mercury

30 Fig. 6 shows curves for the various machines plotted between the electrical input and the developed or available energy in ft-lb. at the orifice and at the machine end of the piping system for the machines connected to the particular hose and piping system proposed by the manufacturer, as outlined above for Series *A*. Fig. 7 gives similar curves for the tests of Series *B*.

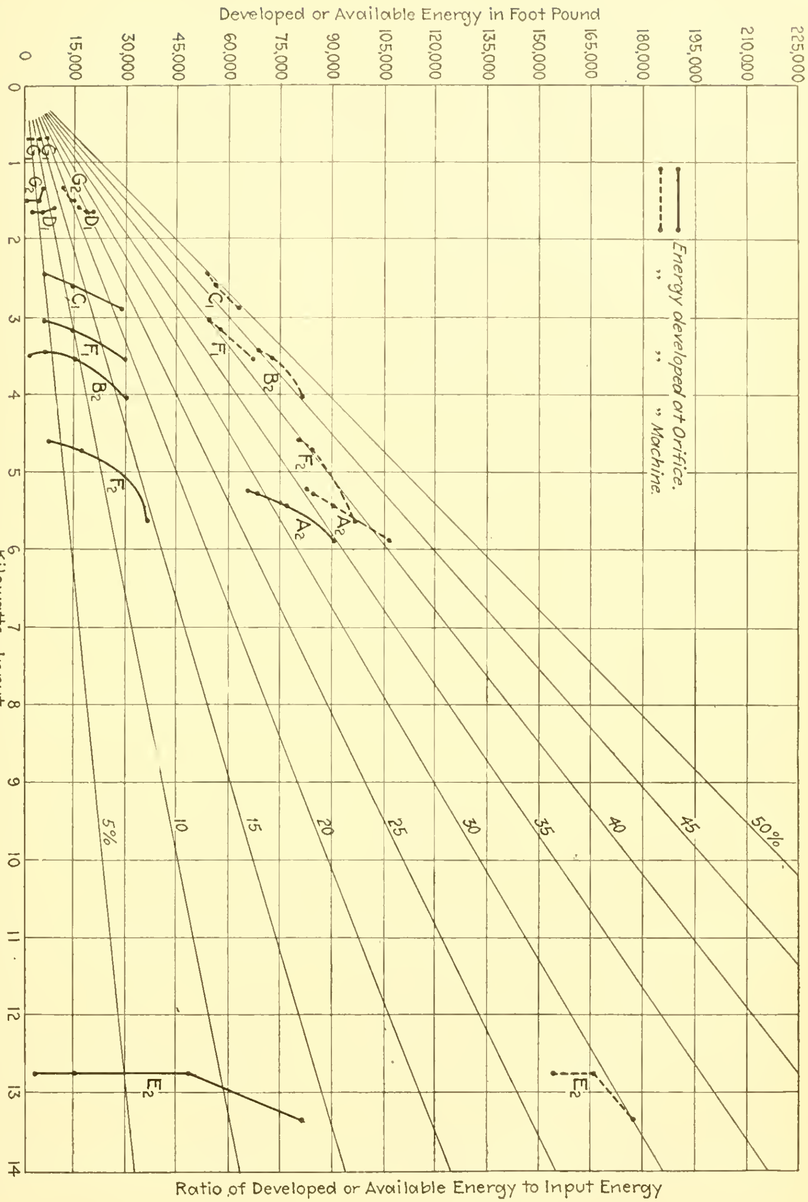


Fig. 7 Curves, with Efficiency Lines, for Energy developed at Machine and at Tool with 3-in. Piping and 1¼-in. Hose; the Same for All Machines

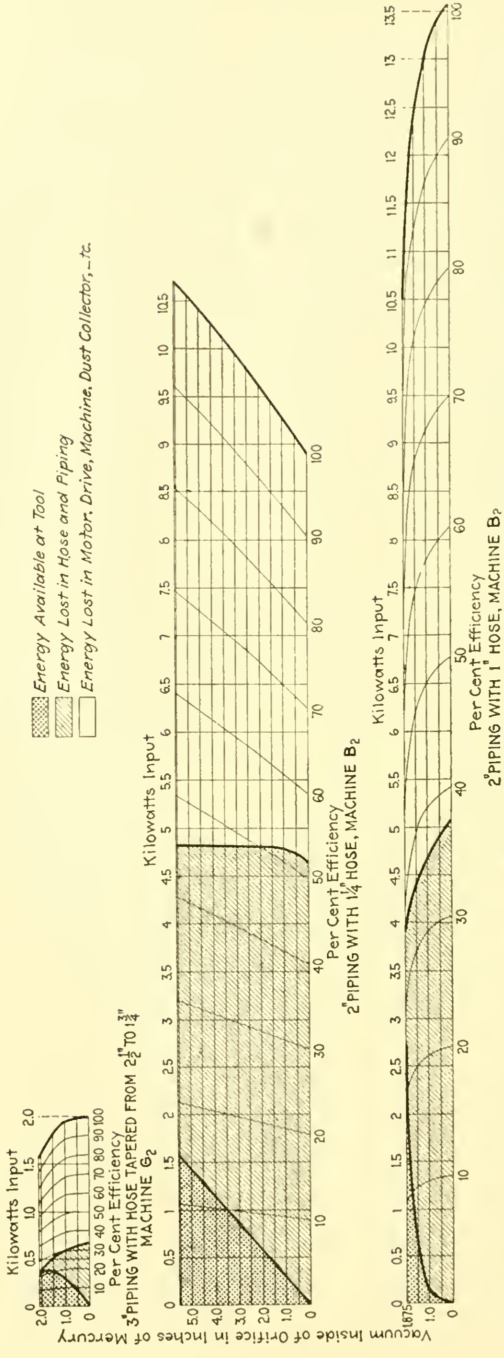


Fig. 8 Graphical Representation of Energy Available at Tool and Losses in Hose, Piping and Machine for a High-Vacuum and a Low-Vacuum Machine

The full lines are for the energy developed at the orifice and the dotted lines for that at the machine.

31 In explanation of Figs. 6 and 7, take curve C_1 in dotted line in Fig 6. For the point of maximum input there is approximately 2.9 kw. or 128,800 equivalent ft-lb. For this input, this vacuum cleaner, which was the single-sweeper, rotary-exhauster type, gave at the machine end of the piping system, 56,550 ft-lb. of energy, or approximately 44 per cent of the total input. For the corresponding input of 2.9 kw., this machine developed at the end of the hose approximately 28,080 ft-lb. of energy, as shown by the corresponding curve in heavy line. This was approximately 22 per cent of the total input, or half the energy available at the machine end of the piping system and represents the condition of greatest restriction of the end of the hose. By similar comparisons, Figs. 6 and 7 give interesting data covering the range of efficiency in production of energy at the tool and at the machine for the various outfits tested. The ratio between the developed or available energy and the input energy is shown by the radiating lines. It is interesting to note that for two-sweeper machines the input ranged from less than 2 kw. to over 13 kw. for machines with piping and hose as proposed to accomplish the same specified results at the tool. The great difference in power consumption was mainly due to the difference in sizes of piping and hose, particularly the latter. To make this more conspicuous the two-sweeper machines having the lowest and highest power consumption as shown by the curves G_2 and the curves B_2 have been chosen. On these curves are marked conspicuously in larger circles the points coinciding with 1-in. vacuum inside the orifice.

32 Fig. 8 gives for the tests of Series *A*, graphical comparisons of these two machines as regards the power to drive, the losses through machine, piping and hose system and the energy available at the tool end of the hose. The upper diagram is for a single-stage fan machine operating in a 3-in. system and two 75-ft. lengths of hose tapering from 2½ in. at the piping inlet down to 1¾ in. at the tool. The lower diagram is for a rotary exhauster type of machine, operating on a 2-in. piping system with two 75-ft. lengths of 1-in. hose, which was the size submitted by the manufacturers for the tests. The middle diagram gives the results for the latter machine when operating on the same piping system but with two 75-ft. lengths of 1¼-in. hose, which was the smallest size permitted by the specifications.

33 These diagrams are made for power consumption losses and available energy under the full range of test conditions. Selecting, for example, the specification requirements of 1-in. vacuum inside the orifice, it is interesting to note that the machine of the upper diagram handled approximately 89 cu. ft. of free air per sweeper; the machine of the lower diagram 49 cu. ft. of free air per sweeper with the 1-in. hose and approximately 88 cu. ft. with the 1¼-in. hose, as will be seen by Fig. 4. The vacuum at the machine for G_2 to accomplish this work was only 2 in. of mercury while with B_2, with the 1-in. hose, it was 14¾ in. of mercury and with the 1¼-in. hose 10.8 in. of mercury. It is interesting to note for the 1-in. vacuum inside of the orifice, that with G_2 less than 2 kw. were required to drive the outfit and of this energy 68.8 per cent was absorbed in the machine and dust collector, 16.2 per cent in the piping system, and 15 per cent was available at the tool. For B_2 using the 1-in. hose, over 13-kw. input was required and of this 65¼ per cent was absorbed in the machine, dust collector, etc., 34.51 per cent in the piping and hose system, giving only 1.24 per cent available energy at the tool. The marked increase shown by the middle figure for B_2, using the 1¼-in. hose with other conditions the same, is interesting. There is a total input of 9.25 kw. of which 48.27 per cent is consumed by the machine, dust collector, etc., 48.58 per cent by the piping and hose system, and 3.15 per cent is available at the tool. Changing the two 75-ft. lengths of hose from 1 in. to 1¼ in. decreased the input requirements approximately 30 per cent and increased the available energy at the tool 150 per cent. Similar comparisons can be made for other vacua inside the orifice. Corresponding volumes can be obtained from Fig. 4.

34 Fig. 8 pictures some facts that will be startling to those who have not thought about the marked saving in power and the increased ability to do work that result from the use of larger hose and piping. The clear parts of the diagrams in this figure represent energy absorbed by the machine, including motor and dust collector losses, etc. The hatched portions of the diagrams represent losses in hose and piping. The double-hatched parts of the diagrams represent energy available at the tool. The important query is: What would the machine B_2 do if it were put on the piping and hose system of G_2?

The tests to determine the ability to do work, including power consumption, were conducted by Prof. H. C. Anderson and the writer. For a care-

ful analysis of the machines as machines, the author is indebted to a committee consisting of Prof. John R. Allen, of the University of Michigan; Mr. Charles H. Treat, chief designer of the American Blower Company, and Mr. Howard E. Coffin, vice-president and chief engineer of the Hudson Motor Car Company. In the acceptance tests which came a little later, he is indebted to Prof. E. J. Fermier, of the Agricultural and Mechanical College of Texas. All of these gentlemen are members of the Society.

STANDARD INVOLUTE GEARING

MAJORITY REPORT OF THE COMMITTEE ON STANDARDS FOR INVOLUTE GEARS

An outline of the work contemplated by the Committee on Involute Gears was presented to the Society at its joint meeting with the Institution of Mechanical Engineers in England three years ago, and since then the experiments on friction losses in gear teeth have been continued at the Massachusetts Institute of Technology by H. S. Waite, under the supervision of Professor Lanza, and in Philadelphia by Everett St. John at the writer's plant under his own direction.

2 The roller bearings originally provided in the apparatus for measuring the friction losses in the transmission of power were found to be the cause of serious variations in the results obtained at successive trials. The rollers developed a tendency to travel longitudinally and cause at times excessive friction by end thrust against their retaining rings, while at other times they ran freely, and thus it became impossible to distinguish accurately between the friction in the bearings and the friction in the teeth. Another difficulty developed in the alignment of the driving shaft, upon the accuracy of which the results were found to depend to a very great extent, and to overcome these difficulties, the testing machine, as previously described, was remodeled. Ball bearings were substituted throughout for the roller bearings originally employed, and one of the supporting knife edges was discarded and in its place was substituted a pair of annular ball-bearings surrounding the driving shaft to act as a fulcrum for the measurement of the driving torque. These changes entailed some sacrifice in convenience of adjustment and manipulation, but they were attended by compensating advantages in the accuracy of the results obtained, and it may now be confidently asserted that under ordinary working conditions the friction loss between the teeth of cut gears and pinions seldom exceeds one or

---

Presented at the Spring Meeting, Baltimore, 1913, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. Subject to revision.

two per cent of the power transmitted and is practically independent of the obliquity of action.

3 The length of the addendum exerts a much greater influence than the obliquity of action, as shown by experiments made on a pinion having nominally 15 deg. obliquity, but an unusually long addendum. These gears were among those cut by Mr. Bilgram to demonstrate the practicability of making involute gears of moderate obliquity to run with small pinions and with each other. Here the addendum is prolonged as shown in Fig. 6 of the previous report,[1] and, as would naturally be expected from a theoretical analysis, the friction loss is considerably increased, the readings taken running from 1.6 per cent to 2.8 per cent as against 1 per cent to 2.2 per cent for the other types. These special gears, however, are not uniform in their proportions and strictly speaking are not interchangeable in the common acceptation of that term, because the center distance between mating gears is not constant for different combinations having the same total number of teeth. At the same time it is interesting to note the influence of the addendum as the dominating cause of friction in involute gearing, regardless of obliquity. Therefore, as far as friction is concerned, there can no longer be any doubt that the obliquity may be increased as far as necessary to avoid interference between a rack and the smallest pinion with which it is expected to engage.

4 By common consent, or, as the outcome of good practice, pinions with less than 12 teeth are seldom found in first-class machinery, and for an interchangeable involute system of external gearing, extending between the limits of a rack and any assumed pinion, it has been shown by Mr. Flanders in his admirable paper which led to the appointment of a committee on gearing, that the addendum adopted fixes the minimum obliquity to avoid interference between two limiting pinions, and that the obliquity adopted fixes the maximum addendum between the limiting pinion and a rack. Therefore, having given a 12-toothed pinion with standard addendum equal to one module, it follows that the obliquity of the system in which 12 is the smallest number of teeth must be 24 deg., and to reduce this obliquity, we must either reduce the addendum or increase the minimum number of teeth in the system. But since 12 has been generally adopted as the minimum number of teeth in all well established systems, a reduction in obliquity must be sought in a reduced addendum, and coming down to 22½ deg., or one-

[1] Trans. Am. Soc. M. E., vol. 32, p. 823.

quarter of a right angle, it appears that the addendum cannot exceed $\frac{7}{8}$ module or about 0.28 pitch.

5 In such a system the arc of action varies from 1.23 for two 12-toothed pinions to 1.39 for a rack and pinion. Large gears running together may have an arc of action as high as 1.5, but such combinations as generally occur in practice do not cover a greater arc of action than a 12-toothed pinion and rack. Coming down again to 20 deg. obliquity we find that the addendum can not exceed 0.7 module or about 0.22 pitch to avoid interference between a rack and a pinion of 12 teeth, but with gears of 80 teeth or less, it is possible to make the addendum 0.75 module or 0.24 pitch as is done in the 20-deg. stub-tooth. Since gears of more than 80 teeth are unusual, these proportions cause no interference in the great majority of cases, or so little as to be practically imperceptible. In this system the arc of action varies from 1.12 for two 12-toothed pinions to 1.25 for a rack and pinion, and the average for various combinations is not far from the latter figure. A great many gears of this type are in service and give excellent satisfaction, and, as will be seen from the tabulated results of experiment, they consume somewhat less power in friction than the other types tested, with the exception of the B. & S. Standard, which now appears to have the lead, although in the previous experiments a difference was found in favor of the stub-tooth. These apparent variations in friction may be due to errors in readings taken with roller bearings, and although the B. & S. Standard has a longer addendum than either the stub-tooth or the proposed new standard, its active or effective addendum may really be less in new gears by reason of the modified forms used to avoid interference. However this may be, contact must sooner or later be extended over the whole addendum as the natural result of wear, at which time the greatest loss in friction would be anticipated in teeth with the greatest length of addendum. The differences however are slight and hardly worth consideration in the selection of a standard. But, in reducing the obliquity from $22\frac{1}{2}$ deg. to 20 deg. we have also reduced the arc of action, and coming down again to $14\frac{1}{2}$ deg. obliquity we find that the addendum for a 12-toothed pinion and a rack can not exceed 0.38 module or about 0.12 pitch, and that the arc of action becomes actually less than the pitch. Such a system is, therefore, impossible, and the so-called $14\frac{1}{2}$-deg. involute system, which is better known as the B. & S. Standard, necessarily includes other curves than involutes. In this system the addendum is one module and the arc of action varies

from 1.35 for two pinions of 12 teeth to 1.47 for a rack and pinion with an average for various combinations of about the same amount. This long arc of action contributes, of course, to smoothness in running when the center distances are right, but the compound curves used in forming the teeth do not admit of the variation in center distance which is known as one of the chief advantages in the involute over all other forms of gearing.

6 It is well known that all forms of gear teeth tend to wear out of shape and that the distribution of wear on involutes is more unequal than on cycloidal forms, but the unequal wear naturally relieves the pressure on the points of involute teeth more than upon those of other forms and causes a redistribution of pressure calculated to favor smoothness and quietness in running. To some extent this is also true of the $14\frac{1}{2}$-deg. modified involute standard, the gears of which furnished by the Brown & Sharpe Mfg. Co. were remarkably well made and ran under certain conditions with comparatively little noise, but whether the quiet running of these gears should be ascribed to some peculiar merit in the forms of the teeth or simply to superior accuracy in forming and spacing is a question not yet clearly determined. In regard to this Mr. Waite remarks as follows:

> The very smooth sound of the B. & S. gear as compared to the others was especially noticeable at low speeds and light loads, where the difference in the quality of the sound as well as quantity was very markedly in favor of the B. & S. gear. I believe this was largely due to the fine finish of the tooth surfaces.

7 But, of course, it may have been due to superior workmanship in forming and spacing, or as claimed by some advocates of this standard to a peculiar merit in the modified forms of the teeth which are involutes near the pitch line and more or less cycloidal in the remote portions of the faces and flanks. If the flanks of the 12-toothed pinion are radial, as they appear to be, the modification of the points of the teeth of the mating rack is necessarily cycloidal, but no exact information has been given and no effort has been made by the committee to discover the modifications used, because the key to any system of gearing is known to lie in the form adopted for the rack tooth, and when this is used as a generator, all other forms in the system naturally follow as a matter of course.

8 A good deal has been said and written about the advantages of the B. & S. Standard which cannot be denied, and it is so well established and so generally liked by its users that it will undoubtedly continue in favor regardless of objections such as may be raised against it from various points of view. The cycloidal system which

preceded it was also a good one and for many years it had no serious rival, but neither of these is an involute system and cannot claim the advantages inherent in the involute form of tooth.

9 The committee was appointed to investigate the subject of interchangeable involute gearing, and if found desirable, to recommend a standard or standards. Some of its members have favored the B. & S. Standard or none at all, while others could not admit the necessity for any modification of involute forms and preferred a solution which would avoid interference by the use of such obliquity and addendum as would reach the desired end.

10 A majority of the committee believes that a standard system of involute gearing should include in its scope a 12-toothed pinion, and all combinations between that and a rack, and that the most desirable system from every point of view is that which insures absolute freedom from interference between all combinations, with a liberal arc of action abundantly to cover the pitch in every case. To meet these conditions, nothing better has been found than an obliquity of $22\frac{1}{2}$ deg. and an addendum of $\frac{7}{8}$ module or 0.28 pitch, to which should be added for completeness a dedendum of one module, and fillets generated by a rack tooth with rounded corners prolonged to one module.

11 Such a system has very decided advantages against which must be weighed the objections raised as to journal pressure, back lash and wear. Although the thrust between centers may be 50 per cent greater than for the B. & S. Standard, it has been shown repeatedly that this additional thrust, when compounded as it must be with the tangential driving force, adds less than 5 per cent to the actual journal pressure, and it is therefore not a serious consideration. In regard to back lash, it may be said that the same care in cutting should produce equally accurate results, and that although the same depth of wear will certainly cause back lash to increase with obliquity, compensation for this appears in the fact that the greater the obliquity the better the distribution of wear. This combination of obliquity and addendum also makes very strong teeth and the obliquity adds materially to the facility with which they can be milled or hobbed, and ground when need be, after hardening. Special considerations will no doubt always influence the choice of these two variables, obliquity and addendum, and in some classes of machinery where the pinions may never have less than 15 or 18 teeth, less obliquity might reasonably be employed, but for all kinds of practice in general, a majority of the committee favors the adoption of

SUMMARY OF RESULTS

Brown & Sharpe 14 1/2 Deg. Addendum—1 Module

Tooth Load, Lb.	325 r. p. m. Total Friction	325 r. p. m. Bearing Friction	325 r. p. m. Tooth Friction	535 r. p. m. Total Friction	535 r. p. m. Bearing Friction	535 r. p. m. Tooth Friction	870 r. p. m. Total Friction	870 r. p. m. Bearing Friction	870 r. p. m. Tooth Friction
1000	0.018	0.001	0.017	0.017	0.001	0.016	0.015	0.001	0.014
2000	0.014	0.001	0.013	0.013	0.001	0.012	0.011	0.001	0.010
3000	0.014	0.001	0.013	0.013	0.001	0.012	0.011	0.001	0.010

20 Deg. Involute Stub-Tooth. Addendum—3/4 Module Approximately

Tooth Load, Lb.	325 r. p. m. Total Friction	325 r. p. m. Bearing Friction	325 r. p. m. Tooth Friction	535 r. p. m. Total Friction	535 r. p. m. Bearing Friction	535 r. p. m. Tooth Friction	870 r. p. m. Total Friction	870 r. p. m. Bearing Friction	870 r. p. m. Tooth Friction
1000	0.022	0.001	0.021	0.023	0.001	0.022	0.018	0.001	0.017
2000	0.016	0.001	0.015	0.015	0.001	0.014	0.012	0.001	0.011
3000	0.018	0.001	0.017	0.016	0.001	0.015	0.013	0.001	0.012

Proposed 22 1/2 Deg. Standard. Addendum—7/8 Module

Tooth Load, Lb.	325 r. p. m. Total Friction	325 r. p. m. Bearing Friction	325 r. p. m. Tooth Friction	535 r. p. m. Total Friction	535 r. p. m. Bearing Friction	535 r. p. m. Tooth Friction	870 r. p. m. Total Friction	870 r. p. m. Bearing Friction	870 r. p. m. Tooth Friction
1000	0.020	0.001	0.019	0.022	0.001	0.021	0.021	0.001	0.020
2000	0.014	0.001	0.013	0.013	0.001	0.012	0.013	0.001	0.012
3000	0.013	0.001	0.012	0.013	0.001	0.012	0.013	0.001	0.012

Bilgram 15 Deg. Addendum Variable

Tooth Load, Lb.	325 r. p. m. Total Friction	325 r. p. m. Bearing Friction	325 r. p. m. Tooth Friction	535 r. p. m. Total Friction	535 r. p. m. Bearing Friction	535 r. p. m. Tooth Friction	870 r. p. m. Total Friction	870 r. p. m. Bearing Friction	870 r. p. m. Tooth Friction
1000	0.029	0.001	0.028	0.029	0.001	0.028	0.023	0.001	0.022
2000	0.025	0.001	0.024	0.021	0.001	0.020	0.017	0.001	0.016
3000	0.024	0.001	0.023	0.022	0.001	0.021	0.019	0.001	0.018

In these experiments, the teeth were lubricated with cylinder oil, the greater part of which was thrown off by centrifugal force, leaving the surfaces in a condition which might be described as slightly greasy.

$22\frac{1}{2}$ deg. obliquity with an addendum of $\frac{7}{8}$ module. That such teeth will run smoothly and efficiently has been clearly demonstrated, but the experiments have not been sufficiently prolonged to determine the effects of wear and the resulting noise. A good deal has been accomplished, however, as shown by the summary of the results obtained by Mr. St. John. These are substantially the same as those obtained by Mr. Waite, but differ slightly in some particulars, easily explained by the difficulties in construction under which Mr. Waite labored and the improved apparatus used by Mr. St. John. Journal friction on the ball-bearings used in these experiments is almost a negligible quantity and the figures given for friction on the teeth are so consistently confirmed by repeated trials that there can be but little if any doubt of their truth.

12 As pointed out by Mr. Gabriel,[1] the field for experimental research is so large that the coöperation of all interested should be secured and a fund be raised for the purpose of employing competent engineers to conduct exhaustive tests with suitable apparatus, and in this opinion the writer is in hearty accord after attempting in a small way to carry on a series of experiments upon one phase only of the problem. But as now constituted and without substantial resources at its command, the Committee on Standards for Involute Gears has but little time or means for experimental research and it has probably accomplished all that can reasonably be expected of it. Its members differ in their view points so widely that but little hope of a unanimous report has been entertained and the above is presented simply as the report of the majority, leaving the way open for dissenting members to file separate reports if they choose to do so. Under the circumstances the writer suggests that the work of the committee be considered as finished and the committee discharged.

WILFRED LEWIS, *Chairman*	*Members Committee*
GAETANO LANZA	*on Standards for*
HUGO BILGRAM	*Involute Gears*

No report has been prepared by E. R. Fellows and C. R. Gabriel, constituting the minority.—EDITOR.

DISCUSSION

LUTHER D. BURLINGAME. This question as to what is the best system of gearing for general use, a question which has been in the air for a number of years, is now sharpened by the recom-

[1] Trans. Am. Soc. M. E., vol. 32, p. 838.

mendation by the committee of a definite plan. This plan while frankly admitted by the committee as not giving the best results as to quiet running and efficiency, is nevertheless recommended by them largely because of the theoretical advantage of having the teeth a true involute throughout their entire length, thus taking a position which would seem to be giving up substance to secure shadow, a recommendation to abandon a system having not only the advantages of quiet running and efficiency, but also the further advantage of being long established and extensively used, and to adopt one which is new, and which would involve great expense in tools, cutters, etc., in changing over and would lead to the confusion naturally attending the addition of another system to that already so firmly established as not to readily be replaced.

It has been pointed out repeatedly in the previous discussion of this subject that in practice the best results are not obtained by making the teeth truly involute their entire length, this being true even when no modification is necessary in order to include a 12-tooth pinion; but rather that the points of the teeth should in any case be eased off to an extent such as experience has shown will give the best results for quiet running. Shortening the teeth does not accomplish this desired result unless the points of the shorter teeth are also eased off, thus still further shortening the working surfaces.

P. V. Vernon, representing a prominent British manufacturer of machine tools, discussing the earlier presentation of the investigations of this committee by Mr. Lewis at the joint meeting in England three years ago,[1] said that his firm had made long and costly experiments with a view of obtaining a system of gears that would run silently at high speed. The results of the experiments which his own firm and others had made had proved that there was one kind of gearing which was quieter than all others, namely the gear with "faked" teeth. It was well known that gears which gave the quietest results in running were those on which an empirical correction of tooth form had been made (referring to the B. & S. Standard).

This opinion is fully corroborated by the tests made under the direction of this committee. In Par. 5 it is admitted that the B. & S. Standard gears run with less friction and more

[1] Trans. Am. Soc. M. E., vol. 32, p. 837

quietly than gears of any other system tested. The report, however, refers to previous experiments as showing other systems to give better results, in spite of the fact that the committee condemned these previous experiments because the roller bearings used in them "were found to be the cause of serious variations in the results obtained at successive trials." On the other hand the improved apparatus, which demonstrated that the B. & S. Standard gears run more quietly and with less friction than any of the other systems of gearing tested, has been so perfected that while the "changes entailed some sacrifice in convenience they were attended by compensating advantages in the accuracy of the results obtained."

It does not seem to come with good grace from the members of the committee signing this report to minimize the importance of the results now obtained because these results are opposite to what they would wish in order to support their theory; or for them to throw the matter off with the statement that "the differences, however, are slight and hardly worth consideration." After the committee have gone to such trouble and expense as to test these very features of friction and noise and have emphasized their importance in the past, as where Mr. Lewis in his previous report[1] said that these experiments should "throw a flood of light on the problem in hand," it seems rather late in the day to say that it is "hardly worth consideration," even if the differences were slight. If I understand the tabulated results the differences are not slight. Taking all the speeds and tooth loads tabulated, the B. & S. Standard is shown to run with an average of 12 per cent less tooth friction than the best of the other systems tested. For the highest speed the B. & S. Standard shows 22 per cent less tooth friction. Assuming the same percentage of gain in durability and quiet running the difference cannot be considered as slight and hardly worth consideration.

The statement in Par. 6 that the 14½-deg. gears showed superior running qualities probably because of better workmanship, would hardly seem a plausible one as all of the gears under test were cut by experts. Such a statement looks like an attempt to explain away facts to help a theory.

I will venture the assertion that the difference in favor of the 14½-deg. gears will show even more favorably as compared with

[1] Trans. Am. Soc. M. E., vol. 32, p. 823.

the others, after having been run to a point where all the sets show wear; also that they would show up to greater advantage if all of the sets were run with a given degree of error in alignment, that is, assuming that the other gears are cut with a true involute curve the entire length of the tooth.

The report is misleading when it says of the gears with 14½-deg. pressure angle that "they do not admit of the variations in center distance which is known as one of the chief advantages in the involute over all other forms of gearing." That they do in practice allow of such variation can be demonstrated by the gears of this system now in the possession of the committee, and the favorable comparison in this respect with other systems, will, it is believed, be even more evident as the gears become worn, the easing off of the points of the teeth being such as to reduce the wear and minimize its evil effects. This additional length of tooth thus serves a useful purpose and is believed to be one of the chief reasons for the quiet running of these gears as shown in the tests reported, as it gives an easy action of approach instead of having a sharp corner with its tendency to a gouging action, as in the case of a short tooth made involute its entire length.

Noise means wear, and quiet running not only means less racking of the nerves, but greater durability and financial saving. Less wear means less back-lash, as does also the smaller pressure angle where a given amount of wear produces less back-lash than in the case of the greater pressure angle.

Such conditions of wear, inaccuracy of alignment and varying center distance, are the practical conditions under which the majority of the gearing in use is run, and any system which does not most fully provide for such needs cannot be recommended for general adoption.

I trust that it may not be felt that, as representing the Brown & Sharpe Mfg. Co., I am coming forward to oppose any change from the established standard simply for commercial reasons. If commercial reasons were the ones governing, a change might be encouraged which would throw the burden of equipping with new cutters and hobs on the manufacturing public, because this change while proving expensive for the user of cutters, would bring new business to the cutter manufacturers. It would mean to the user not only the loss and confusion due to having part of his equipment of cutters of one system and part of another, not

interchangeable with each other, but it would require more cutters in a set to maintain the same standard as at present, i. e., where eight cutters now make a set to cut from a 12-tooth pinion to a rack for ordinary work and where 15 cutters make a set for work where the conditions are more exacting, the adoption of a system with a greater pressure angle and shorter teeth would require more cutters in each of these sets, all of which would make business for the manufacturer of cutters.

My company is equipped to make cutters or hobs by the proposed system as well as by the present, but in the interests of the user and for the reputation of the maker, such cutters would not be made involute the full length of the tooth unless specifically ordered to be so made.

Long experience with the gear question and its many pitfalls, leads us to take a conservative position at this time and to give a word of caution as to any action which in the light of future experience might be found to have been hasty. We believe that no action should be taken leading away from the present established gear-tooth system until after the exhaustive experiments under actual working conditions recommended by the committee have been made, and have proved conclusively that some new system meets those working conditions better than that now in common use.

Henry Hess. The committee have done yeoman work. They have given enormously of their time and themselves carried a heavy burden of expense, and the special thanks of our members are due them.

There is one decided objection to the Brown & Sharpe system: It does not lie in the performance of those gears; it lies in the fact that no one knows what that system is. It is a system of a certain general type modified, as its sponsors say, necessarily, but aside from those manufacturers, no one person knows definitely what that modification is. It may be laid down as axiomatic that no system can hope to receive recognition as a standard which is confined to a single firm, no matter what the eminence of that firm nor how well it may have performed its work, not even though it have the deservedly high standing that B. & S. means the world over.

The Committee. In the discussion of this report, Mr. Burlingame seems to lose sight of the fact that, until the Brown &

Sharpe Standard has been mechanically defined, it is really anything that Brown & Sharpe choose to make, and, as stated by Mr. Hess, no one, aside from its sponsors, knows exactly what it is. Some criticism has also been made on the want of uniformity in the cutters furnished for the same purpose at different times, and although some variation might reasonably be expected in the output of such products, it is impossible for the user to know what is right or what is wrong in the absence of a comprehensive definition which might enable others skilled in the art to make and use such cutters.

Mr. Burlingame also loses sight of the fact that the Brown & Sharpe Standard is not preferred exclusively on account of its running qualities and that "the very smooth sound of the Brown & Sharpe gear was especially noticeable at low speeds and light loads." Quite as many, if not more correspondents, preferred the stub tooth, and a further comparison of the Brown & Sharpe gear with the sample 22½-deg. involute gear, has satisfied the majority of the committee that although the Brown & Sharpe test gears run more smoothly, that is with less vibration in the noise per revolution of the gear wheel, there is really very little difference in the average volume of sound. The 22½-deg. gear produces pulsations of sound which coincide with the revolutions of the wheel and Mr. Bilgram has no doubt that these are due to a slight eccentricity arising from cutting this gear on an overhung arbor. Unfortunately no apparatus has as yet been devised to visualize the noise and so enable definite comparisons to be made at different times. It was hoped at the outset that something of this sort might be developed at the Massachusetts Institute of Technology, but in this the committee has been disappointed and it recognizes the difficulty of making accurate comparisons between the hum of a given pair of gears while running and the hum of another pair which ran some time before. Such impressions are naturally very elusive, but it can hardly be denied that smoothness or uniformity in the noise indicates uniformity in the work and a high degree of accuracy in spacing the teeth. This admission in favor of the products of the Brown & Sharpe Manufacturing Company does not lead, however, to a conclusion in favor of the Brown & Sharpe Standard, because any standard would undoubtedly appear to the best advantage when so perfectly applied.

The committee does not doubt that for a 14½-deg. involute

system, the modifications embodied in the Brown & Sharpe Standard to avoid interference and promote interchangeability are as complete and effective as can be devised, but a majority of the committee does not recognize the necessity for so little obliquity in involute gearing as to cause any modification whatever in the true involute form. This attitude has been condemned as subservient to a theory and the contention has been made that a question of such importance should not be treated as an academic matter, but the majority of the committee does not recognize any limit to the application of sound principles nor any point in the problem to be solved beyond which such principles must give way to empirical methods. In the choice of an interchangeable system of involute gearing to include a 12-toothed pinion and a rack, it is perfectly clear in the first place that an obliquity of 14½ deg. will not give enough arc of action between two 12-toothed pinions to cover the pitch and that when such pinions are made to run together they do not run as involute gears. If their flanks are radial as they appear to be in the B. & S. Standard, such pinions are necessarily more closely related to the discarded and condemned cycloidal system than to the involute, with the merits and defects of both only partially realized.

If the teeth do not bear to their ends when new they must do so later on as the result of wear, and if they show less friction because contact does not take place over the whole addendum when new, this is just as it should be from a theoretical standpoint. The difference, however, is slight, and if experiments were needed to prove that obliquity alone has no effect upon the friction of the teeth themselves, the evidence adduced should help to establish that fact. The close relation between friction and the working length of the addendum is also clearly indicated in the experiments and both of these relations are fully sustained by analysis.

It is admitted that a slight increase in journal pressure will result from an increase in obliquity, but it cannot be said with certainty what the obliquity of the Brown & Sharpe Standard really is, because the nominal obliquity of 14½ deg. is all that is known, leaving the obliquity of the modifications in doubt. It is certain, however, that the increase in pressure due to an obliquity of 22½ deg. cannot exceed 5 per cent and in all probability it is considerably less. This increase in journal pressure

has always been the chief argument against an increase in obliquity, but it does not appeal to the majority of the committee as the most important consideration in the selection of a standard system of interchangeable involute gearing.

Nothing has been said about the number of cutters in a set nor the effect of the approximations which are necessarily made in milling an unlimited number of gear sizes with a limited number of cutters. The number of cutters in a set naturally depends upon the degree of accuracy desired. Brown & Sharpe cover the field very well with 8 standard cutters, they do it better with 15 and still better for cycloidal teeth with 24 cutters; but another well known maker has never been satisfied with less than 24 cutters in a set, whether involute or cycloidal in form. To avoid pounding on the ends of teeth, the cutters selected to form a set should never be used on gears having fewer teeth than the number on which they are formed. This is the well-established practice of Brown & Sharpe and it is undoubtedly correct, but it simply mitigates the evil of using the wrong cutter.

When gears are hobbed or generated on a gear shaper, one cutter serves to make all sizes on the principle that gears which run with the same master wheel acting as a cutter, will run together. This principle is correct if the addendum of the master cutter is prolonged to cover the same arc of action as a rack cutter, and for the proposed root clearance of $\frac{1}{8}$ module, such master cutters should not have less than 30 teeth, or the equivalent in a hob, but of course smaller cutters can be used by increasing their addendum and consequently the dedendum of the gear cut, which is not a vital matter. The spring in the machines used also affects the results obtained, and in general it may be said that all gear teeth are more or less approximate in form whether milled or hobbed or planed. They are, therefore, all subject to improvement or depreciation, as the case may be, from wear, and this deals with quantities too minute to be measured or corrected in the cutters themselves.

Interchangeable gear teeth which are true to form and evenly spaced generally carry the whole load on one tooth at and near the pitch line, and divide it between two teeth at the remoter parts of the arc of action. In such gearing, it is very unusual to have more than two teeth engaged at one time and not at all desirable, since a large arc of action between large gears means a short

arc of action between small gears of the same series. But it is absolutely necessary to cover the pitch and to cover it well. Having done this by means of an obliquity and an addendum which avoid interference throughout the series contemplated, the relief supposed to be needed at the ends of the teeth to promote smoothness in running takes care of itself through wear. There is no need of any modifications or allowances for this purpose in involute gearing because the tendency of wear is to relieve the points and concentrate pressure in the neighborhood of the pitch line. Further than this, gears cut with cutters formed to a smaller number of teeth are necessarily relieved at their points more than the best action requires and the full arc of contact is attained only by wear.

On the other hand, cycloidal gear teeth tend to wear uniformly under constant pressure and therefore more in the neighborhood of the pitch line, where the load is undivided, than at their points where the load is divided. Consequently there is a greater tendency for such teeth to wear less at their ends and pound. It is no wonder, therefore, that the cycloidal system is "dead," as declared by Mr. Vernon in the discussion referred to by Mr. Burlingame. But if, at one time, when in favor, its demise had been predicted by an analysis of the effect of wear, as it surely might have been, the advocates of empirical methods, who know something better than theory and want to be shown in a practical way, would no doubt have stood by this standard against any reasonable arguments based upon broad general principles. But there is no difference between theory and practice when both are properly understood and applied. Each supplements and aids the other in arriving at the truth, and any sort of interchangeable gearing which is not based upon some theory of the proper action of gear teeth, is certainly not a system. It may work well enough or very well indeed as a composition, but it lacks the binding force of a unitary principle which makes the reproduction of every cutter absolutely determinate and reliable.

The proposed standard covers a wide range of numbers from 12 teeth to a rack. It gives a large increase in strength over the Brown & Sharpe Standard and a better distribution of wear. The wide angle enhances the freedom in cutting by any process, and the involute form without alteration or correction of any kind simplifies the problem of grinding after hardening.

Although no action has been taken to establish the number of

cutters in a set nor the lateral clearance between cut teeth, it is evident that the same number of cutters will approach perfection in the proposed system as well as in the Brown & Sharpe Standard, and since contact on both sides of the teeth is impossible in any approximation, it is suggested that the thickness of all cutters at the pitch line, measured on the chord, be taken at one-half the pitch measured on the pitch circle. The clearance would then be a maximum for two engaging 12-toothed pinions and in this case it would be barely 0.003 in. for 1 in. pitch, or in general not more than 0.003 of the pitch, whatever that might be. This would reduce the clearance almost to the vanishing point and yet leave enough to relieve unavoidable errors in forming and spacing. Of course, clearance or backlash will always increase with wear, but ordinarily when transmitting power there is no rattle or noise from this cause. In cases where all backlash must be eliminated and the teeth made to touch on both sides while running, the completion of the gears by grinding on each other puts them in a special class which can hardly be considered interchangeable. They may wear in this way out of their original shape but not out of rolling contact which covers an infinite variety of shapes beside the Brown & Sharpe Standard.

So, while admitting that the Brown & Sharpe Manufacturing Company has probably made the best possible adaptation of 14½-deg. obliquity to practical use, the majority of the committee cannot, for the reasons stated, accept this composition as the ideal form of gearing which should be adopted for an interchangeable involute standard.

ECONOMICS OF CENTRAL STATION HEATING

By Byron T. Gifford, Chicago, Ill.

Junior Member of the Society

The first meeting of the newly organized section of the Society in Chicago was held on April 9, 1913. About 55 members and guests were in attendance and Paul M. Chamberlain, chairman of the meeting, presided. The question of holding meetings jointly with the Western Society of Engineers was discussed, and it was decided that such an arrangement would not be attempted at present, although it might be brought about at a later time. It was further voted that in addition to the professional meetings planned for the coming year, one meeting devoted almost entirely to social matters should be held in order that the members might become better acquainted.

Byron T. Gifford, manager of the engineering department of the American District Steam Company, then read a paper on the Economics of Central Station Heating, an abstract of which follows.

ABSTRACT OF PAPER

There are three important branches of central station heating: (*a*) the production of heat units; (*b*) the distribution of this product; and (*c*) making the service attractive to the consumer.

The first of these, the generation of heat, may be handled by three distinct methods: by direct firing, or "straight fuel burning" plants; by an electric generating plant with heating as a by-product; and by a combination of a by-product plant and a heating plant.

Owing to many causes the heating plants of the future will be of the last type. In an arrangement of this kind, electricity, for instance, can be produced much more cheaply than is possible in the most economical electric plant, and there are a number

The American Society of Mechanical Engineers, 29 West 39th Street, New York.

of ways of disposing of this by-product: It may be sold to an existing electric plant at a wholesale rate; a market may be made for it by creating industries requiring a fairly large amount of electricity at a comparatively low price. The author has in mind the case of an industry which has supplied to it 400 kw-hr. of electricity 20 hours per day, 365 days per year, at less than 1 cent per kw-hr. The net income to the heating company from this by-product is more than sufficient to meet the payments of the bond interest, taxes and insurance of the entire property. This additional income, amounting approximately to $11,000, is being handled with an increased operating cost of $2200, as compared with the operation of the plant the year previous when no electric current was generated. With a simple or a twin Corliss engine a kilowatt of electricity can be generated under conditions which exist in the average central heating plant with 45 lb. of steam. Assume for example a heating plant serving 200,000 sq. ft. of steam radiation. This load gives an average demand on the boilers of about 40,000 lb. per hour, which, if sent through a simple or twin Corliss engine, will develop 880 kw-hr. of electricity. Assume that this electricity is sold to some consumer for 1 cent per kw.; at this price 1 cent would be realized for every 45 lb., or 22 cents for every 1000 lb. of steam delivered to the heating mains before it had left the station. The history of central station heating has proved that a rate averaging 60 cents per 1000 lb. for steam is reasonable and can be procured from any heating consumer. This would mean 82 cents per 1000 lb. for the steam generated, which is a good return on the investment.

Heating plants in the United States at present vary in size from a connected load of 10,000 sq. ft. of radiation to a connected load of 1,750,000 sq. ft. of radiation. These plants are built in towns of upward of 1000 people.

There are few electric generating plants that can put a kilowatt-hour of electricity on their switchboard below a cost of ½ cent per kw-hr., and there are also few electric plants that can generate and distribute to the primary side of their transformers for a cost of 1 cent per kw-hr., especially when the overhead and fixed charges are considered. Heating plants, with electricity as a by-product can do this, and this fact alone will make a place for central heating plants. Some of the larger operating com-

panies are doing this at the present time and others are building properties to operate along this plan.

Regarding the second point, distribution, in water works or in gas properties the losses from distribution consist of leaks and pressure drops due to friction which is caused by insufficient pipe capacities. In central heating there are these two losses to contend with, and in addition the loss from radiation, called "line loss" by central heating engineers. Leaks are a decided detriment to heating pipe line, and the loss from this source is probably more serious than was at first supposed. Assume for example, a hole ¾ in. in diameter in a pipe line containing steam at 5 lb. pressure. With an evaporation of 7 lb. of water per lb. of coal, this leak will cost 23 tons of coal per month. A leak of this size is equally as detrimental in a hot-water heating system. The loss from friction affects, of course, the initial pressure to be carried on the heating mains, and consequently affects the back pressure to be carried on the engines.

As to the detriment of too high a friction loss, in a 3-in. steam line 1000 ft. long, carrying 1000 lb. of steam per hour, the friction loss will be equal under average conditions approximately to 1460 B.t.u. per hour. This same load carried 1000 ft. in a 3½-in. line will show a friction loss equal approximately to 500 B.t.u. and a 4-in. line under the same conditions will lose only 240 B.t.u. from friction.

The radiation loss from central heating is even more important than friction loss, from the B.t.u. standpoint. There is a number of styles of underground insulation in use to-day, which lose anywhere from 0.03 lb. to 0.38 lb. of steam per sq. ft. of underground surface per hour.

In order to determine the most economical line to instal it is necessary to combine the friction and radiation losses. Take, for example, a demand of 1000 lb. of steam per hour which must be carried 1000 ft. A 3-in., 3½-in., 4-in. or 4½-in. pipe will do this work, but the most economical size must be determined. The loss from friction would be 1460 B.t.u. per hour on the 3-in. line; 500 B.t.u. on the 3½-in. line; 250 B.t.u. on the 4-in. line and 130 B.t.u. on the 4½-in. line.

Assume a radiation loss of 0.05 lb. of steam per sq. ft. of underground surface per hour; the radiation loss from the 3-in. line will be approximately 45,000 B.t.u. per hour; 3½-in. line approximately 52,000 B.t.u.; 4-in. line approximately 58,000 B.t.u.;

4½-in. line approximately 65,000 B.t.u. Combining these two losses, it is seen that the 3-in. line is the most economical to instal, provided it does not affect the heating station conditions by causing excessive back pressure on the engine.

Experience has shown that a 3-in. line carrying this load the given distance will have a drop in pressure of about 7 lb., and as it is necessary to have 1 lb. pressure at the end of the line, it means that the back pressure at the station would be approximately 8 lb. If this pressure is excessive it would be necessary to run a 3½-in. line, which would give a back pressure of less than 5 lb. The difference in cost between a 3-in. and a 3½-in. line is comparatively small. The cost of material is somewhat less for a 3-in. line; the cost of labor is approximately the same.

To show the value in dollars and cents of efficiency in underground insulation, a piece of line insulated with a construction that will lose 0.05 lb. of steam per sq. ft. of underground surface per hour may be compared with a line insulated with a construction that will lose 0.14 per lb. per sq. ft. per hour. Both constructions are found in everyday practice. For this purpose an 8-in. line 1000 ft. long will be considered. Such a pipe has 2.25 sq. ft. of surface per lineal foot. In the first case the line loss will amount to 112 lb. of steam per hour; in the second case to 215 ft. Assuming a generation cost of 30 cents per 1000 lb., in a season's operation (from October 1 to June 1, or 5832 hours) a line loss in the first case will equal $195 per year and in the second case $550 per year.

The money saved, therefore, will be the difference between these two figures, or $355 per year. This is 10 per cent on $3550, an amount which can be spent to instal the more efficient construction. Since the difference between these line losses is 0.09 lb. of steam per sq. ft. of underground surface per hour, and since the example assumed consisted of 1000 ft. of 8-in. line, which is 2250 sq. ft. of surface, it is seen that for every 0.01 lb. of steam saved on this 8-in. line, approximately $400, or 20 cents per sq. ft. of underground surface, can be spent.

Another interesting example is the comparison of two insulations on an entire underground heating installation. This installation consists of approximately 800 ft. of 12-in. pipe line, 1200 ft. of 10-in. pipe line, 3600 ft. of 8-in. pipe line, 4200 ft. of 6-in. pipe line, and 7300 ft. of 4-in. line and surface. The number of square feet of underground surface in this system is equal

approximately to 30,000 sq. ft. Comparing two insulations, one with 0.04 loss and one with 0.09 loss (difference 0.05) by the following formula which the author has derived, the more efficient insulation in this case will be worth $30,000 more than the less efficient:

$$N \times S \times L \times C$$

where

$N =$ the difference between the two insulations in hundredths of a pound of steam lost per hour

$S =$ the number of square feet of surface per lineal foot of pipe

$L =$ the length of pipe

$C =$ a constant based upon the cost of steam per thousand pounds and the number of hours in the heating season

Where the steam costs 30 cents per 1000 lb. and the heating season is 5900 hours, the value of C is 21 cents.

Regarding the third point, making the service attractive to the consumer, it is not necessary, perhaps, to wrap it up in a good looking package, but it is necessary to have it attractive in price and quality. That this class of service is attractive is shown by the fact that central heating plants, with few exceptions, have had no trouble holding their consumers. It is this one fact, as much as anything else, that has put many heating plants into trouble. They have been tempted to serve a larger territory or more consumers than their plants could economically handle, and they have been tempted also to extend their services without due regard to the economics of the proposition.

As to the best method of selling the heating service, experience has shown that the meter basis is the most equitable. The rate will depend upon local conditions. A number of companies are selling steam on the meter basis, with a sliding scale rate; others have devised a maximum demand or readiness to serve rate, both of which work out admirably in practice. The quality of the service is always sufficiently attractive to obtain a large percentage of the possible consumers.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

In a paper read at the Cambridge meeting of the Institution of Mechanical Engineers entitled A Few Notes on Engineering Research and Its Coördination, G. H. Roberts advocates the necessity of a definite and generally recognized system for making known the results of the numerous private researches and experiments which are continually being carried on. He makes the following statement: "The author is not unaware of the fact that many arrangements are now, and have for some time been, in operation giving references to work carried on elsewhere, and need only instance the excerpts published in the Proceedings of the Institution of Civil Engineers, of the Iron and Steel Institute, and by The American Society of Mechanical Engineers, to mention but a few. These references, excellent though they be, are, however, usually in the nature of general records of works accomplished rather than of researches carried out with definite objects in view."

It would require a more complex organization than probably exists in the case of any of the societies mentioned to establish a clearing house and advance depositary of engineering information in connection with their publications. There can be no doubt, however, that an international exchange of information concerning engineering investigation would be of great advantage and the suggestion should have consideration as indicating a direction for future development. In the Foreign Review of The American Society of Mechanical Engineers all that has been attempted has been to bring to the American engineer, in as clear a form as space permitted, such data published abroad as might be of interest to him in his day's work. The letters received at this office, as well as the fact that abstracts from The Journal are frequently reprinted in the form of regular articles by American and British technical papers, indicate that, in its own field, the Review helps the English speaking engineer to know at least what has been done abroad, even if it cannot as yet tell him of work not ready for complete publication.

THIS MONTH'S ARTICLES

The article of Hoefer on the flow processes in the ascending pipe of the Mammoth pump, though referring more particularly to this particular apparatus, applies equally well to other types of air-lift pumps, and may be of interest to hydraulic turbine engineers. Data of the Allevard tests on water hammer bring out an important fact, viz., that the water conduit pipe subject to water hammer, due to sudden closure of the outflow opening, must be made equally strong all along its length, although this is not necessary where provision is made for gradual closing only. These tests also confirm in part the Allievi theory, of which a second installment is reported in this issue. This theory is considered, and generally so recognized in Europe, of such importance that a very complete abstract, showing as far as possible the mathematical processes used by the author, is given.

Bartel indicates the economic limits of the gasification of low-grade fuels, and attempts to prove that, as matters stand now, a gas-fired boiler with a steam turbine is more efficient for large installations than a straight gas engine plant, even though the latter is more efficient thermodynamically. In the section Mechanics the first part of an article on shock absorption in power vehicles is abstracted, as well as an article on the experimental determination of the coefficient of cyclic variation by means of an eddy-current tachograph. In the same section Z. Carrière describes a convenient and certain cinematic method of measuring air velocities, particularly convenient for calibrating pitot tubes and similar instruments.

The next section contains a description of a recording load indicator showing the load fluctuations of an engine, and thus giving data interesting both in testing engines, and in many cases of their industrial operation, e.g., in isolated plants, rolling mills, etc. The Bourlet apparatus for measuring the vibrations of solid bodies in case there is no fixed support for the measuring apparatus will probably be of particular interest to automobile and aeroplane manufacturers. Data and charts in connection with blowing-off of boilers, and results of tests on resistance offered to the flow of superheated steam through smooth and corrugated expansion pipes will be found in the section Steam Engineering. In other sections will be found articles on torsion indicators, strength of soft steel bars with drilled and reamed holes, electric atomization of metals, etc.

Hydraulics

Investigation of Flow Processes in the Ascending Pipe of the Mammoth Pump (*Untersuchungen über die Strömungsvorgänge im Steigrohr eines Druckluftwasserhebers*, K. Hoefer. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 30, p. 1175, July 26, 1913. 9 pp. 17 figs., *etA*). Tests of flow processes in the so-called Mammoth pump. It was found that some data of tests do not agree with the values obtained by calculation and the author came to believe that this was due to the failure of taking into consideration the velocity of flow of the air with respect to water, when passing through the ascending pipe. It is impossible to determine this "relative velocity of air" theoretically, and the tests described have been undertaken for the main purpose of determining it experimentally. In all the tests water at ordinary temperature was used, and the ascending pipe had the same diameter of cross-section throughout its length. The tests were made in the machine construction laboratory of the Technical High School at Berlin.

The first series of tests was to determine the velocity of air bubbles rising through the water, as a function of the diameter of the bubble. Under the assumption that the bubbles are perfect spheres, the following formula ought to hold good:

$$v_L = \text{const.} \sqrt{\delta(\gamma_w - \gamma_L)} \qquad [1]$$

where δ is the diameter of the air bubble, γ_w specific weight of water, and γ_L specific weight of air. This equation shows that (*a*) at the same distance from the surface of the water, a larger bubble moves with greater velocity than a smaller one, and (*b*) the velocity of an air bubble rising through water constantly increases owing to the expansion of the air, and consequent increase of δ. Instead of following the theory as set forth in this equation, the tests have however presented the rather startling relation between diameter and speed shown in Fig. 1A, where the speed rises rapidly at first with the diameter, reaches a certain maximum value at $\delta = 1.1$ mm (0.043 in.) approximately, and begins to decrease slowly, until it reaches a minimum, from whence on it again begins to rise. This remarkable behavior of the curve may be partly explained by the fact that, contrary to the assumption of equation [1], the bubbles are not spherical; the main reason why the speed decreases is because of the fact that when the bubbles have diameters less than 1.1 mm, they rise through the water vertically, and, if deflected, resume a vertical direction again when free to do so. If, however, the diameters are even a little in excess of 1.1 mm, the path of the bubbles become helical, which explains the slower speed in the purely vertical direction. The transition from straight line to helical motion could be clearly observed in several cases. As the diameter increases still further, beyond 3 mm, the helical path of the bubble loses its regularity, and at the same time the shape of the bubbles becomes more and more unlike a sphere; the resistance of water tends to flatten them, so as to make the horizontal diameter greater than the thickness of the bubbles. The rising branch of the curve in Fig. A may be determined approximately by the equation

$$v_L = 0.275\, \delta^{1.4} \text{m/sec. for } \delta \leqq 1.1 \text{ mm} \qquad [2]$$

and

$$v_L = \frac{1}{\delta} + 0.0379\, \delta^{0.6} \text{m/sec. for } \delta \geqq 15 \text{ mm} \qquad [3]$$

For 1.1 mm $< \delta <$ 15 mm a simple mathematical relation between δ and v_L cannot be established. The above shows definitely that there is no similarity whatever between the theoretical equation [1] and the experimental equations [2] and [3]. Further experiments have shown that the speed of the motion of the bubbles through water remains the same when the pressure is somewhat in excess of the atmospheric, tests having been made with pressures up to 1.3 atmospheres gage.

A further series of tests was made to establish directly the velocity of the air bubbles in the ascending pipe of the Mammoth pump (the description of the methods used has to be omitted owing to lack of space). It has been found that, at first, the velocity in the higher parts of the ascending pipe is below that in the

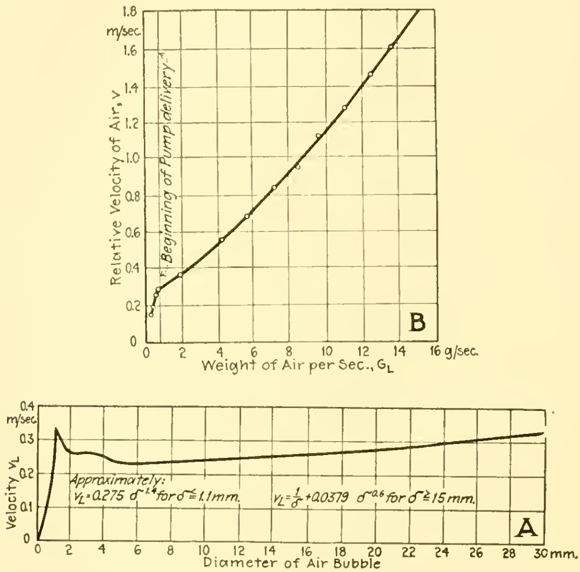


Fig. 1 Flow of Air Through Water

lower strata, but increases again when the upper half of the pipe is reached. The average speed in one representative test has been found to be 0.28 mm (0.0109 in.) per sec., the air bubbles having diameters from 3 to 5 mm. Since the speed from Fig. 1A for bubbles of these diameters appears to be only 0.25 mm (0.01 in.) per sec., the speed of the smaller bubbles does not materially seem to affect the average speed of the mass of air flowing. The velocity of air increases with the increase in the amount of air flowing, as shown graphically in Fig. 1B, which shows also that the relative air velocities (relative with respect to the water) are considerably greater than was usually supposed, the increase in velocity with the increase in the amount of air flowing being due probably to the prevalence of large bubbles, and *these high values of the air velocity v are probably the cause of the low efficiency of the Mammoth pump.* The author states in conclusion that while the data reported here give an insight into the theory of the Mammoth

pump, they are still insufficient for its theoretical calculation, which would become possible only when it was known how the air velocity v is affected by the inside diameter of the ascending pipe, and by the relation between the draft and delivery head, or $E:F$. These experiments also fail to show how v may vary with still larger amounts of air flowing. The article also contains methods for calculating some of the elements of operation of Mammoth pumps, not reported here owing to lack of space.

French Hydrotechnical Society (*Société Hydrotechnique de France, La Houille Blanche*, vol 12, no. 6, p. 178, June 25, 1913. 5 pp., *eg*). Subsequent to the Congress of White Coal in 1902, a French turbine commission was appointed, with an extensive program, but comparatively modest means at its disposal. It did a certain amount of useful work, but the lack of means prevented it from accomplishing all that its program promised, so that when in 1912 the French Hydrotechnical Society was formed, the commission voted to disband, and to leave to the new society the task of finishing its work. As most of the work done by the commission has been duly published, only the part referring to the action of water hammer will be reported here owing to its connection with the articles of Allievi and de-Sparre, published in this and the preceding issues of *The Journal*. Tests made at Allevard have shown that water hammer is produced by damped waves, in conformance with the theory. The first wave, absolutely flat on top, conforms fully to the views of Allievi, and by a calculation of overpressure due to the water hammer by using the formula $y - y_0 = \frac{a}{g}\Delta v$, a value is found which is in full accord with the experimental values. But, contrary to the theory of Allievi, all the following waves have a damped *sinusoidal* shape. The period, i.e. the length of waves of the water hammer, which in the Allevard experiments has been found to be equal to 1.84 seconds, also does not fully agree with the theory of Allievi, and is longer than $4L/a$, where L is the length of the conduit in meters, and a is the speed of propagation of the waves, determined from the formula

$$a = \frac{9{,}900}{\sqrt{48.3 + K\frac{d}{e}}}$$

On manometric curves certain very marked irregularities are noticeable, in the form of flattening out of the curve at certain spots, or pressure considerably below the atmospheric, or overpressures at other spots, all of these irregularities being evidently due to the influencee of a parasite wave, which is reflected when the diameter of the pipe varies, and comes back to the outflow orifice. Various curves taken from pressure records of experiments in which the flow of water was not entirely stopped, clearly show the extreme rapidity of the damping produced by a continuation of flow through the orifice, there being in that case only one or two waves, as against 20 and more in the case of complete closing.

The numerous diagrams taken in the case of sudden opening of the outlet clearly show the positive water hammer following the negative water hammer initially caused by the sudden opening. Since, however,

continuing flow very rapidly produces damping, the amplitude of the positive water hammer is notably below that of the negative. By placing recording pressure indicators at various points along the conduit, it has been found that the wave produced by a sudden closure of the conduit outflow opening travels with nearly the same intensity all along the conduit until close to its upper free opening, which is in accordance with the theory of Allievi, and is of particular importance to conduit designers as it shows that the pipe must be of such strength throughout as to be able to support an overpressure not only in its lower part, but practically up to the top free outlet. This, however, applies only to sudden overpressures, because a gradual closing produces a variation which in its propagation meets with the interference due to other waves coming in the opposite direction, or produced by changes of section of the pipe, and more or less substantially reducing the water hammer action in the upper parts of the conduit. In general the Allevard experiments have shown that the Allievi theory is correct as far as the first wave is concerned, but that the following waves, probably modified by the viscosity of the water, friction against the pipe walls, and interference on the part of other waves, direct or reflected, tend to become rapidly sinusoidal, even though the first wave following the sudden closure of the conduit outflow opening was trapezoidal.

Theory of Water Hammer (*Théorie du coup de bélier*, L. Allievi, *Bulletin technique de la Suisse Romande*, vol. 39, nos. 11 and 14, pp. 121 and 159, June 10 and July 25, 1913. Serial article, not finished. *tA*). Continuation of the abstract published in *The Journal*, August 1913, p. 1287. Let us assume that in a conduit, the permanent operation of which is characterized by y_o and v_o, a period of disturbance is created by manipulating the pipe closer, the beginning of this manipulation coinciding with the time $t=0$; by t let us denote some instant between 0 and μ, belonging, through being in that interval, to the phase of the positive blow; let us further provide with indexes:

	1	2	3	4	etc.

the values of the variable quantities corresponding to the instants

	t_1	$t_1+\mu$	$t_1+2\mu$	$t_1+3\mu$	etc.
of the	1st	2d	3d	4th	etc. phase,

and let us denote by capitals the variations occurring at the section of the abscissa $x=0$, adjacent to the pipe closer. Equations [2] and [3] (*The Journal*, August 1913, pp. 1287–1288) can then be written as follows:

$$\left.\begin{aligned} Y_1 &= y_o+F_1 \\ Y_2 &= y_o+F_2-F_1 \\ Y_3 &= y_o+F_3-F_2 \\ &\ldots\ldots \end{aligned}\right\} \quad [4]$$

$$\left.\begin{aligned} V_1 &= v_o-\frac{g}{a}F_1 \\ V_2 &= v_o-\frac{g}{a}(F_1+F_2) \\ V_3 &= v_o-\frac{g}{a}(F_2+F_3) \\ &\ldots\ldots \end{aligned}\right\} \quad [5]$$

The first general consequence that can be deduced from the nature of the systems of equations [4] and [5] is that the series of load values Y_1, Y_2, Y_3, etc., as well as the corresponding series of velocity values V_1, V_2, V_3, V_4, etc., separated from one another by intervals of time equal to the duration of a phase, constitute *interconnected series*, i. e. series of values which depend only on the initial conditions and the positions of the pipe closer at the instants: t_1, $t_1+\mu$, $t_1+2\mu$, etc., but neither on the intermediary positions of the pipe closer, nor on the values of Y and V through which they may have passed in the intervals separating these instants.

The analytical expression of this series formation is obtained by eliminating F_i from the systems [4] and [5]. To do this, add each equation of [4] to the one preceding it and subtract each equation [5] from the one preceding it. The following is then obtained:

$$\left.\begin{aligned} Y_1-y_o&=\frac{a}{g}\,(v_o-V_1)\\ Y_1+Y_2-2y_o&=\frac{a}{g}\,(V_1-V_2)\\ &\ldots\ldots\ldots \end{aligned}\right\}\qquad [6]$$

If we denote by ψ the ratio between the variable area of the outflow opening, and the area of the section of the conduit, then:

$$\psi_o=\frac{v_o}{u_o},\quad\text{and}\quad \psi_i=\frac{V_i}{u_i}$$

where u_o and u_i are the efflux velocities corresponding to loads y_o and Y_1; further, η may denote the ratio $\dfrac{\psi}{\psi_o}$, or the ratio of the actual opening of the outflow orifice, to that opening of it ψ_o which is taken as a unit.

Assume further that

$$y_o=\frac{u_o^2}{2g};\quad Y_i=\frac{u_i^2}{2g};\quad V_i=\eta_i u_i\frac{v_o}{u_o},$$

and introduce into the equation the characteristic ρ which may be defined by the equation:

$$\rho=\frac{av_o}{2gy_o}=\frac{av_o}{u_o^2}\qquad [7]$$

the following is then obtained:

$$\left.\begin{aligned} u_1^2-u_o^2&=2\rho u_o\,(u_o-\eta_1u_1)\\ u_1^2+u_2^2+2u_o^2&=2\rho u_o\,(\eta_1u_1-\eta_2u_2)\\ &\ldots\ldots\ldots \end{aligned}\right\}\qquad [8]$$

which is a system of quadratic equations where the only unknown magnitudes are the velocities of outflow u. The author, in accordance with the first of his principles, proceeds now to substitute for the absolute values of u relative values referred to u_o, which can be done by dividing all the equations of the system [8] by u_o^2, if $\zeta_i=\dfrac{u_i}{u_o}$, hence:

$$\left.\begin{aligned} \zeta_1^2-1&=2\rho\,(1-\eta_1\zeta_1)\\ \zeta_1^2+\zeta_2^2-2&=2\rho\,(\eta_1\zeta_1-\eta_2\zeta_2)\\ &\ldots\ldots\ldots \end{aligned}\right\}\qquad [9]$$

which connects the values of the interconnected series ζ_1, ζ_2, etc., and which the author calls *fundamental system* because, as shown later, it contains the entire

theory of the water hammer. The first of the equations of [9] can evidently be expressed in the form

$$\zeta_o^2+\zeta_1^2-2=2\rho\ (\eta_o\zeta_o-\eta_1\zeta_1)$$

since $\eta_o=1$, and $\zeta_o=1$, so that the fundamental system may be considered as resulting from the repeated application of the general equation

$$\zeta_{i-1}^2+\zeta_i^2-2=2\rho\ (\eta_{i-1}\zeta_{i-1}-\eta_i\zeta_i)$$

to a series of instants separated from one another by intervals u. *This single equation governs all the hydrodynamic phenomena which may occur in a conduit fed from a constant level reservoir and provided at the end with an outlet opening of variable cross-section.* The name of *conduit characteristic* given to ρ is justified by the fact that equation [7] expressing it, when introduced into [9], is sufficient to supply the fundamental system [9] with all the characteristic elements of the conduit, viz.: working load and speed y_o and v_o, and diameter, thickness and elasticity of the conduit, the latter through being contained in the velocity of propagation a. The only element of the conduit not contained in ρ is its length L, which however serves only to determine $\mu=\frac{2L}{a}$, the value of which determines the rhythm of the interconnected series of values of ζ_i. It is therefore shown that the relative value of the intensity of the water hammer, which is the real object of investigation, depends not only on the laws of variation of the outflow openings (contained in η), but also on the characteristic ρ, and it becomes, consequently, important both to establish the actual significance of this characteristic, and to fix the limits of numerical values which it may have within the limits of technical application. The article is to be continued.

Internal Combustion Engineering

Economic Limits of Gasification of Low Grade Fuels (*Wirtschaftliche Grenzen der Vergasung minderwertiger Brennstoffe*, D. Bartel. *Feuerungstechnik*, vol. 1, no. 20, p. 363. July 15, 1913. 1½ pp., *g*). The editors of the publication state in an introductory notice that they do not agree with the views expressed in the article. The author does not believe in the wide application of gas producers and gas engines in large power plants, even though the gas engine appears to convert into power a larger percentage of the heating value of the fuel than the steam turbine (24 per cent as against 20 per cent). Against the success of the gas engine militates the fact that it cannot be operated efficiently in units larger than 5,000 h.p., or say 3500 kw. The speed of large gas engines is 87 to 94 r.p.m., which is ridiculously low if compared with the speed of steam turbines (3000 r.p.m. for units under 6000 kw., and at least 1000 r.p.m. for larger units). It is therefore easy to understand why gas engine plants cost so much more than steam engine plants, the first cost of the plant being often nearly treble. (Table 1.)

Altogether the cost of installing a plant of 4500 kw. driven by gas engines is about 2,000,000 marks, and only half as much with steam turbine drive, so that the cost of generation of power in the first case will be from 15 to 20 per cent higher than in the second case *even if gas be obtained free as a by-product of another manufacture.* As a matter of fact, however, the connection between by-product manufacture and power

generation is such as to prevent efficient development of the latter, owing to variations in the power load during the day, and its almost entire falling off at night: the gas has therefore at times either to be blown off into the atmosphere, or stored in gasholders, neither of which is likely to improve the economy of the plant. The author believes therefore that the use of gas from low-grade fuels may in the future develop mainly along the lines of the gas turbine, provided it can equal the steam turbine in size and cost, and excel it in efficiency; it being however also possible that the combination of the steam turbine and gas-fired boiler may present another, somewhat devious, but practical solution of the same problem. The author attaches great importance, with regard to the future field of application of gas, to the experiments of Caro and Frank on the production of ammonium sulphate, and of Asmus Jabs on by-produfets of tar, which, if successful, would reduce the cost of gas so materially as to open to it entirely new fields of application.

Mechanics

Experiments on Shock Absorption of Power Vehicles (*Versuche über die Abfederung von Kraftfahrzeugen*, E. Bobeth. *Der Motorwagen*, vol. 16, no. 19, p. 467, July 10, 1913. 4 pp., 7 figs. to be continued *e*). The author fully describes and illustrates by figures the test installation for recording graphically the shocks, as well as for measuring the stresses produced on the various parts of the vehicle. The nature of the phenomenon of shock can be deduced from Fig. 2A. It is assumed that the wheel shown in the figure rolls along its path with a constant horizontal velocity v_h, and when at the point A meets an obstacle B which it has to jump over. At the instant of meeting the obstacle, the wheel has to perform a motion of rotation about the point C of the obstacle, and if the wheel is equipped with rigid tires, and the velocity v_h remains constant while it clears the obstacle, according to the parallelogram of velocities, at the instant of the contact with B there must appear a vertical velocity v_v of finite magnitude. Since, however, at the instant preceding that of striking the obstacle, the vertical velocity of the wheel was equal to zero, its vertical acceleration must be infinite. Actually, the acceleration is finite, because either the obstacle or the wheel undergoes changes of shape, and a good way to keep the vertical forces in finite limits is to use elastic tires, so as to permit

TABLE 1 FIRST COST, IN MARKS, OF PLANT AS FUNCTION OF OUTPUT AND DRIVE

Output in Kw.	Steam Turbine Drive	Gas Engine Drive
750	82,000	190,000
1,000	93,000	220,000
2,500	150,000	420,000
3,500	180,000	550,000
6,000	250,000	....

the obstacle partly to penetrate the tire: the vertical forces increase then from zero, and impart a gradually increasing vertical velocity to the mass of the axle, the wheel and axle executing an oscillatory motion, which depends on the shape of the obstacle, and is transmitted to the wagon body. In the above discussion it is assumed that the horizontal velocity v_h of the chassis and axle remains constant even while the wagon passes over an obstacle. This assumption is usually correct since the mass of the vehicle is so large that the retardation at the instant of the shock may be entirely neglected.

Fig. 2B shows one of the oscillation diagrams obtained, where the curve a represents the vibrations of the axle, and b those of the wagon frame, while c is a curve drawn to the same scale, and showing what the oscillations would have been if the wheel, equipped with a perfectly rigid tire, rolled over the obstruction without losing its contact with the ground. In the latter curve A indicates the instant of first contact between the wheel and obstruction. A' the instant when the wheel is vertically over the middle of the obstruction, and A'' the instant when the wheel loses its contact with the obstruction. The shape of curve c is of course entirely

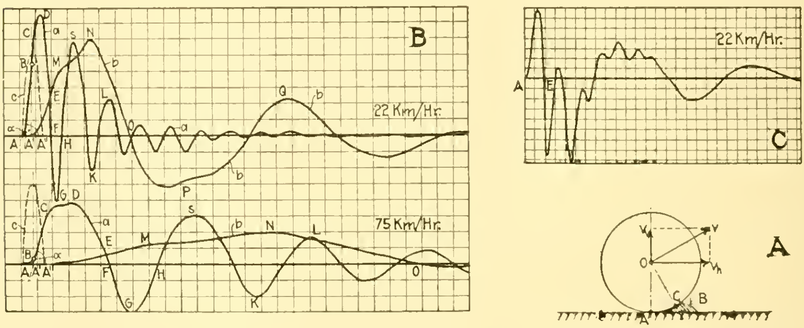


Fig. 2 Shock Vibrations in Power Vehicles

different from that of a showing the actual oscillations in the case of wheels equipped with elastic tires. The gradual rise of the axle is shown in the rising branch ABC of the curve a. A considerable vertical velocity is attained, which does not become zero until D, corresponding to the instant when the forces opposing the upward motion of the axle have entirely consumed the kinetic energy of the axle, and a downward swing of the axle begins. In this downward swing the mass of the axle acquires also a considerable amount of kinetic energy, and consequently moves past its position of equilibrium (indicated on the diagram by the horizontal line), and exerts a certain amount of pressure on the road surface FG until all its kinetic energy is consumed by the road resistance. The road surface pressure produces a second upward swing GHs followed by a series of upward and downward oscillations, gradually decreasing in amplitude; this shows that there are constantly acting forces tending to prevent the propagation of oscillatory movements. As a sequel to axle oscillations appear oscillations of the frame shown in the diagram by the curve

b; these oscillations, being of a secondary nature, lag somewhat behind the oscillations of the axle (primary), and it is of peculiar interest that not only the first, but the second upward swing of the axle as well materially affect the magnitude of the vibrations of the frame. Since the abscissae represent time, the diagram indicates directly the duration of the oscillations; while comparing the durations of oscillations of the axle and frame, it should be borne in mind that the axle is a mass oscillating between two elastic systems, the wagon springs on one hand, and the tires on the other, while the frame is supported only by one elastic system, the wagon springs; its period of oscillation is therefore usually longer than that of the axle, while with the latter the period of the first oscillation is on the average longer than that of the subsequent oscillations. The diagram affords also an easy way of determining the velocity of vibration of the axle or frame at each moment, through the fact that the velocity $v = \frac{ds}{dt}$, and is represented by the tangent to the oscillation curve.

It is further of considerable interest to determine the relative motions between the axle and frame. This may be deduced from Fig. B: the points of intersection of the curves *a* and *b* indicate moments when the axle and frame occupy mutual positions corresponding to their state of equilibrium; when the curve *a* is above the curve *b*, the axle is closer to the frame than the state of equilibrium warrants, while the location of *a* below *b* indicates their drawing wider apart. Fig. 2C represents a diagram of these relative motions, and shows that the variations of these relative positions of the axle and frame with respect to one another occurs at an extremely high speed, considerably higher than the maximum velocity of the component absolute motions. The article is to be continued.

Experimental Determination of the Coefficient of Cyclic Variation (*Die experimentelle Bestimmung des Ungleichförmigkeitsgrades*, Wilhelm Riehm. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 137, 1913, p. 1. 32 pp., 28 figs. and *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 28, p. 1101, July 12, 1913. 7 pp. 21 figs. *e*). The author shows that for gas engines particularly and reciprocating engines generally the theoretical velocity diagram derived from the mass-kinetic energy diagram corresponds fairly closely to the actual velocity diagram as long as there are no elastic elements in the transmissions. In practice, however, there is usually a number of influences present producing disturbances in the velocity diagram, and no calculation is possible unless the dynamic influences of all such disturbing forces are taken into account. Sometimes, as in the case of shafts subject to torsional oscillations, the production of such disturbing forces can be shown theoretically, but even there a quantitative determination is both difficult and uncertain. Generally, however, the forces producing cyclic variations cannot be determined theoretically at all, and require some instruments for their determination by actual measurement. The author describes in full an *eddy-current tachograph*, which he designed for this purpose, and which gives a diagram showing all the variations of velocity. Full data of tests for the coefficient of cyclic variations of a 10-h.p. gas engine are also given in the article.

New Method for Measuring the Velocity of Fluids (*Nouvelle méthode de mesure de la vitesse des fluides*, Z. Carrière. *Comptes rendus de l'Académie des Sciences*, vol. 156, no. 24, p. 1831, June 16, 1913, pp. *e*). Pitot tubes, anemometers and similar instruments may be made to be very sensitive, but they cannot be relied upon for measuring velocities: they have to be calibrated empirically, and this is usually done by displacing the apparatus at a given velocity in a supposedly stationary medium. The air never being perfectly calm, a correction is made for wind. This wind is supposed to be feeble, while, as has been shown (Bulletin de l'Institute Aérotechnique, fasc. II, pp. 12 and 13), the velocity in 30 seconds may vary from 1.30 to 2.90 m (4.26 to 9.51 ft.), with a change in direction up to 30 deg. Under these conditions, the correction made for the action of the wind does not correct much, and the calibration is by no means reliable. Owing to these considerations, the author worked out a *process of determining air velocities cinematically*, by incorporating into the air current, along its axis, a jet of steam under low pressure. A bundle of horizontal rays of light is then projected on the jet of steam, after being previously condensed by a crystallizer filled with water. The steam jet vibrates spontaneously, and takes the form of little clouds carried by the air. Individually these clouds are invisible, but may be conveniently observed by means of a rotating vertical mirror. The apparent trajectories of these little clouds appear then as inclined brilliant bands separated from one another by dark intervals, these bands becoming more vertical as the speed of the current of air increases, and that of rotation of the mirror diminishes. Let ϕ be the angle of the bands with the horizontal, V the velocity of the clouds, n the number of revolutions of the mirror per second, d distance from the mirror to the air current. Then

$$V = 4\pi n d \tan g\phi$$

and since the mass of the steam is negligible when compared with the mass of the air which carries it, V soon becomes equal to the velocity of the current of air itself. The velocity of the steam jet must be neither too great nor too small, the best velocity being that of the air current itself; the steam is therefore at low pressure, and may be supplied from a glass vessel. It is as a rule not perfectly dry, but that can cause no error, since the water drops have a more horizontal trajectory, and are more brilliant than the steam. The author describes in some detail the methods of determining the angle ϕ and of producing a uniform rotation of the mirror. The principle of the process described is not new; what is new is the combination of the use of rotating vertical mirrors with the use of a material of nearly the same density as air. This process appears to be applicable only to air or gas currents having a vibration of their own, e.g., those flowing out through an orifice, in which case, as is known, there is always a feeble sound of which the height is proportional to the velocity of efflux, but independent of the size of the orifice.

Measuring Instruments

Recording Load Indicator (*Registrierender Belastungsanzeiger*, *Der praktische Maschinen-Konstrukteur*, vol. 46, no. 15, p. 67 (Section: Allgemeiner Teil), July 17, 1913. 1 p., 1 fig. *d*). It is often desirable to know

not so much the actual *load* on the engine, as its *variations during a certain period*. The apparatus here described is designed to satisfy this want. It is based on the fact that the position of the engine governor corresponds in a certain way to the load; in locomotives and marine engines the link motion does the same thing. While the principle of the apparatus is very simple, considerable constructive difficulties had to be overcome until a reliable apparatus could be produced. In Fig. 3, *c* is a heavy pendulum oscillating in a state of neutral equilibrium, and connected, by means of the springs *b*, with the driving crank *a*, in its turn connected with the governor; the springs are so selected as to take up the entire weight of the pendulum, and thus eliminate friction. To prevent the rise of resonant oscillations between the crank *a* and the pendulum, the lower end of the springs is made adjustable radially with respect to the axis of the pendulum. The apparatus shows the time of occurrence and duration of every

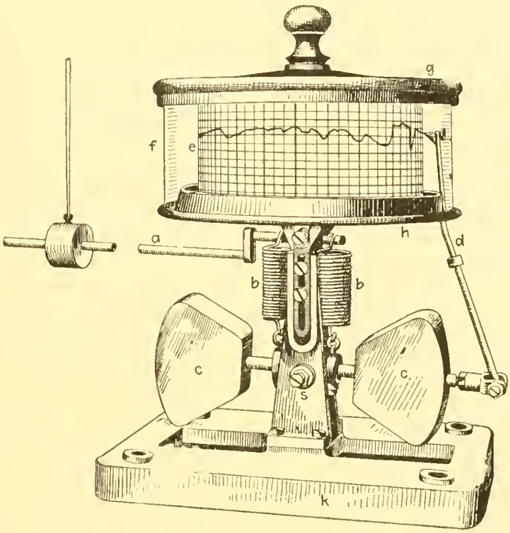


Fig. 3 Recording Load Indicator

variation in load, and may be applied to steam engines of all kinds, whether turbines or reciprocating, internal-combustion engines, hydraulic motors, etc., and is particularly recommended for tests of engine efficiencies, to show that the entire test was made at constant load. The heavy line above the recording curve indicates the curve for full load; the distance between the actual curve in each of its positions and the upper full line shows both the power reserve of the engine at each instant, and the coefficient of exploitation of the engine. The indications of the load indicator may perhaps be made still more illuminating if supplemented by a recording admission pressure gage, and a device for recording the condenser vacuum. For general purposes however the load indicator diagrams will probably be sufficient.

Apparatus for Measuring the Vibrations of Solid Bodies in Motion (*Appareil de mesure des vibrations de corps solides en movement*, M. Gérard. *Revue Industrielle*, vol. 44, no. 2092/27, p. 366, July 5, 1913. ½ p. *d*). Special instruments have to be used for measuring the vibrations of such elements of machinery as the chassis of an automobile or wing of an aeroplane, because there is no fixed support on which to place the registering instrument. Bourlet, working in coöperation with the Duke of Guiche and in his laboratory, has invented a suitable device for this purpose which does not require a fixed support. It consists essentially of two manometric tubes closed at one end and interconnected by a rubber tube of suitable length. To the flexible membrane of the first tube called *receiver* is attached a large and fairly heavy metal disc. This tube is attached directly to the vibrating body in such a manner that the plane of the membrane is normal to the direction of vibrations. The tube will then take part in the vibrations of the body, without disturbing them, provided its mass be small in comparison with the mass of the vibrating body. Owing to its inertia, the metal disc will develop, with respect to the tube, a relative oscillatory inverse motion, and the membrane will thus have a vibratory motion of the same periodicity as that of the main vibrating body. These vibrations are transmitted to the second tube, *recorder*, provided with a stylus registering the vibrations on a rotating cylinder. It is easy to see that the relative motion of the metal disc with respect to the manometric tube consists of: (*a*) main vibratory motion synchronous with the motion to be registered, and (*b*) secondary vibratory motion due to the elasticity of the membrane: the apparatus must of course be constructed in such a manner as to make the secondary as negligible as possible. This is attained by using a thick, well stretched membrane, and a metal disc of large diameter covering the membrane nearly completely, and leaving open only a narrow circular strip. Tests made with an apparatus constructed in accordance with these principles have shown that: (*a*) the secondary oscillatory motion is entirely negligible, in fact practically unnoticeable, so that the frequency of the vibratory motion measured and that of the stylus of the recorder are equal; (*b*) for a given frequency, the ratio $r = \frac{a}{a'}$ is constant when a is varied (a is the frequency of the oscillations to be measured, a' the frequency of the oscillation of the recording stylus); (*c*) the damping r increases when the frequency diminishes. The apparatus must therefore be calibrated so as to determine the value of r as a function of the frequency. It has been found that provided the rubber tube be not wound in too many coils, its shape does not affect the action of the apparatus, so that, within reasonable limits, it may be coiled and uncoiled.

Torsion Meters (*Über Torsionsindikatoren*, Nettmann. *Die Turbine*, vol. 9, nos. 18, 19, 20, pp. 319, 337, and 355, June 20, July 20, July 5 and 20, 1913. 12 pp., 24 figs. *d*). Brief consideration of the theory of torsion indicators, and description of their various types.

Steam Engineering

Concerning Blowing-Off of Steam Boilers (*Über das Abblasen von Dampfkesseln*, W. Hopf. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 27,

p. 327, July 4, 1913. 2 pp., 2 figs. *p*). When the boiler is fed with water which is apt to form undesirable deposits, it is an important problem to know *how to keep the contents of soluble salts in the water in the boiler so as not to let them pass a certain predetermined limit,* and so keep them from forming deposits on the boiler shell and tubes. Blowing-off a boiler is always an expensive proceeding, and must not be done oftener than is absolutely necessary. The permissible contents of salts in the boiler water is determined on the basis of various considerations, such as analysis of the water, type of boiler, demand on the boiler plant, variations of load, use of steam, and finally experience in running the particular plant. The following abstract shows how to determine when to blow-off the boiler. The notation used is: z_o contents of salts in feedwater in grams per liter (only soluble salts being here considered); z_m maximum permissible contents of salt in boiler water in grams per liter; J total boiler capacity in liters, with water up to normal level; s quantity of water evaporated in the boiler per

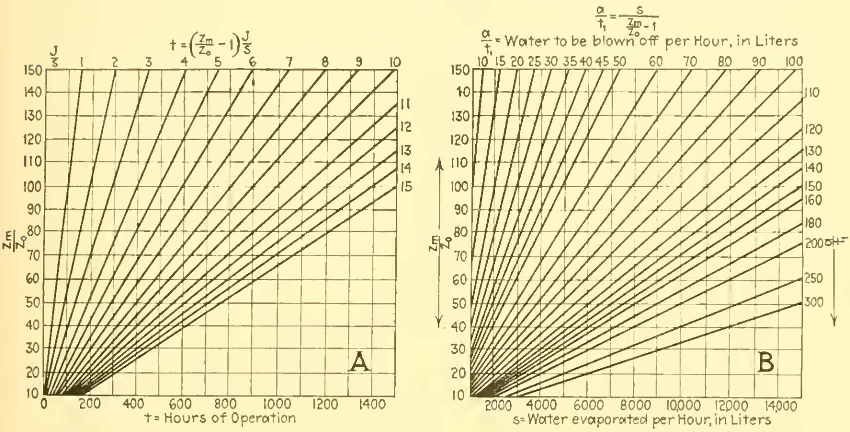


Fig. 4 Blowing-Off of Steam Boilers

hour, in liters. The time t in hours within which the salt content of the boiler water will reach the maximum permissible amount z_m, can be determined from the following equations:

$$z_m \cdot J = z_o \cdot J + Z_o \cdot s \cdot t$$

$$t = \frac{(z_m - z_o)\,J}{z_o \cdot s} = \left(\frac{z_m}{z_o} - 1\right)\frac{J}{s} \qquad [1]$$

This shows that the time t within which the water in the boiler reaches the permissible maximum content of salts depends on the ratio $\frac{z_m}{z_o}$, as well as on the other independent variables. When the water in the boiler reaches the dangerous limit, part of it is blown-off, and the fresh water flowing in soon restores the former level in the boiler. Meanwhile the salt content in the boiler is below the permissible maximum, but rises to it gradually as the evaporation continues, and when this maximum is reached, a new blowing-off becomes necessary. If the amount a of water blown-off be expressed in liters, the periods between

blow-offs, presumably equal, may be determined from the equation (assuming, for simplicity's sake, that the blowing-off is instantaneous):

$$z_m \cdot J - z_m \cdot a + z_o\,(a + s \cdot t_1) = z_m \cdot J$$

which is true since the salt content in the boiler water at the end of the blow-off period must be equal to that at its beginning. Solving this equation for t_1 and $\frac{a}{t_1}$, the following is obtained:

$$z_m \cdot a = z_o(a + s \cdot t_1);\ a\frac{z_m}{z_o} = a + s \cdot t_1;\ \frac{a}{t_1} = \frac{s}{\frac{z_m}{z_o} - 1} \qquad [2]$$

$$t_1 = \left(\frac{z_m}{z_o} - 1\right)\frac{a}{s} \qquad [3]$$

The quantity of water to be blown off after a given time depends therefore on the amount of water evaporated in that time and on the ratio $\frac{z_m}{z_o}$, but not on the capacity of the boiler. The quantity of the water a will be established by the size and type of boiler, at the time of its construction, and equation [3] will give the best intervals for blowing off the boiler. To simplify the application of these formulae, Fig. 4A and B are given. In Fig. A $\frac{z_m}{z_o}$ indicates how many times the salt content in the boiler water exceeds that in the feedwater; $\frac{J}{s}$ shows in how many hours the entire water in the boiler will be evaporated, while t gives the number of hours in which the content of salt as present in the feedwater will be intensified $\frac{z_m}{z_o}$ times. Fig. B gives values of $\frac{a}{t_1}$ for various ratios of $\frac{z_m}{z_o}$ and quantities of steam generated per hour s, the latter from 1000 to 15,000 kg per hour. It is easy to redraw these graphs to American units, by remembering that 1 kg = 2.204 lb., and 1 liter = 0.264 gal. = 0.035 cu. ft.

Resistance to the Flow of Superheated Steam in Smooth and Corrugated Expansion Pipes (*Leitungswiderstand überhitzten Dampfes in glatten und in gewellten Ausgleichrohren*, C. Bach and R. Stücke. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 29, p. 1136, July 19, 1913. 8 pp., 16 figs. *e*). Data of tests made at the engineering laboratory of the Technical High School at Stuttgart, Germany. Five extension pipes were tested, two smooth and two corrugated, with and without lagging; four of these pipes had the inside diameter about 2.2 in. (55 to 56.5 mm), while one, corrugated, had an inside diameter of 4 in. (100 mm). A complete description of the method of test is given in the original. The author starts from the general formula of resistance to flow

$$H = \lambda \frac{l}{d}\,\frac{c^2}{2g}$$

where λ is an experimentally determined general coefficient of resistance to flow; l length of pipe along the axis; d inside diameter of pipe; c velocity of flow in the pipe; $g = 9.81$ (all in metric units); for the height of a liquid column H is then substituted in this formula the pressure fall $p_v = \frac{H}{v}$ 'where pressure fall p_v is re-

ferred to the sq. m. as unit, and v denotes the specific volume. The above formula, with p_v expressed in atmospheres, assumes the following form:

$$p_v = 10^{-4} \cdot \frac{\lambda}{2g} \frac{1}{v} \frac{l}{d} c^2,$$

and hence

$$10^{-4} \frac{\lambda}{2g} = p_v \, v \frac{d}{l} \frac{1}{c^2}$$

if $10^4 \frac{l}{2g}$ be denoted by β, coefficient of resistance to flow, the latter is then equal to

$$\beta = p_v \, v \frac{d}{l} \frac{1}{c^2} 10^8 \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

The tests were made with superheated steam at gage pressures of 5.5 to 12.75 atmospheres at the admission opening to the expansion pipe; steam temperatures of 350 to 364 deg. cent. (662 to 687.2 deg. fahr.), and the steam velocity from approximately 51 to 121 m (167.2 to 400 ft. per sec.) (on p. 1142 the minimum steam velocity is stated to have been 25 m, but this is apparently a misprint—Editor). The values of the coefficient of resistance of flow have been determined and are given in Table 2.

TABLE 2 COEFFICIENTS OF RESISTANCE OF FLOW (SUPERHEATED STEAM)

Pipe No.	Diameter, Mm.	Lagging	β	Type
I	55	None	38.1	Corrugated
I	55	Some	36.2	Corrugated
II	56	None	33.6	Corrugated
II	56	Some	32.3	Corrugated
III	56.5	None	17.9	Smooth
III	56.5	Some	16.35	Smooth
IV	56.5	None	17.8	Smooth
IV	56.5	Some	16.3	Smooth
V	100	Some	49.2	Corrugated

The coefficient of resistance to flow in expansion pipe I is larger than in pipe II owing to the presence, in four places, of contractions reducing the diameter to 53 mm. The coefficient for corrugated pipe is generally about twice as large as for smooth pipe. The coefficient of resistance to flow for the large pipe (100 mm, or 4 in.) is comparatively large because the radii of curvature of the bends are small. It is worth noticing in this connection that Eberle (*Mitteilungen über Forschungsarbeiten*, no. 78, p. 65) has found that the coefficient of resistance to flow for smooth straight pipes is only 10 to 11. On the other hand the corrugated expansion pipe admits of a deflection about 5.5 times higher than a smooth one. The original article contains a complete table of data of tests.

Strength of Materials and Testing

Influence of Drilling of Holes on the Strength of Soft Steels (*Influence du perçage sur la résistance des aciers doux*, C. Birault. *Le Génie Civil*, vol. 63, no. 12, p. 230, July 19, 1913. 2 pp., 2 figs. *e*). The author, in charge of the department of testing of materials at the Ecole Centrale,

Paris, found by tests *that when holes are drilled and then reamed in soft steel bars, the metal materially increases in strength,* the average limit of elasticity improving 12.3 per cent, and the average tensile strength 9.2 per cent. The author gives the following explanation of this phenomenon. In putting together the parts of a test piece broken under tension, it is found that the two ends do not coincide; and that, while the edges make a good contact, the central parts do not, this indicating that the rupture begins at the center, and that the edges have a higher tensile resistance than there is along the axis of the bar. Therefore, if there are several holes drilled so as not to injure the material too much, as might be the case with punching, the average tensile strength of the section across the holes, per unit of metal, will be higher than before the holes were drilled, since each hole creates, so to say, additional edges. To show these differences better in the elongation of the various parts of the test bar, from axis to edge, parallel lines were drawn on a soft steel test piece (without holes), normal to its axis, and at a distance of 10 mm (say 0.2 in.) from one another. After rupture these initially parallel lines looked as shown in Fig. 5, drawn to scale. The limit of elasticity of the material was exceeded in every part of the piece at the time of rupture, and the parallel lines ceased to be parallel in every part of the bar except its ends. Near the section of rupture the lines are concave towards the rupture, elsewhere convex. In general this shows that rivet holes when properly made do not lower the tensile strength of the riveted piece in proportion to the reduction of section.

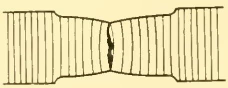


Fig. 5 Distribution of Tensile Stresses in Soft Steel Bars

Electrical Atomization of Metals for Metallographic Investigations (*Die elektrische Zerstäubung von Metallen zum Zweck metallographischer Untersuchungen*, G. Goldberg. *Dinglers polytechnisches Journal*, vol. 328, no. 27, p. 417, July 5, 1913. 2 pp., *dg*). Description of the Svedberg process for the atomization of metals by transferring them into a colloidal solution, for the purposes of metallographic investigations. The electrodes in the form of cylinders of about 6 mm (0.23 in.) in diameter made of the metal to be investigated are fixed in the clamps of a spark micrometer at a distance of approximately 0.25 mm (say 0.01 in.), the whole being submerged in a vessel containing some liquid of solution (ethyl ether was used by Svedberg usually, though it has been found that the nature of the liquid does not essentially affect the course of the reaction). The electrodes are connected on one hand with the secondary circuit of a Rumkorff induction coil (spark about 30 mm (1.2 in.) long, and on the other hand with a shunted-on Leyden jar of considerable capacity (say 0.0045 microfarads). Svedberg has established that for the most effective atomization the capacity must be as large, and the self-induction, ohmic resistance, and length of spark as small as possible. The colloidal solution obtained by this method may be further investigated by an ultramicroscope, while the electrode face may be submitted to the usual metallographic analysis even

though, after the atomization, it has a rather rough appearance. The action of the spark produces on the face of the electrodes a number of little craters, with generally one of larger dimensions, this being probably the starting point of the main spark discharge. These craters have different appearances for different kinds of metals, and, e.g., in the case of several test-pieces of electric steel, it has been observed that the size of the crater increases with the carbon content in the steel. The cementite contents and slag inclusions could also be easily estimated in a similar manner. The quantity of metal atomized was in all cases found to be proportional to the square of the current, and the loss in weight of the electrodes independent of the direction of the current.

Supplementary References

Breguet Ejectair (The Journal, July 1913, p 1183). Cp. Mémoires de la Société des Ingénieurs Civils de France, Ser. 7, vol. 66, no. 5, May 1913, p. 689.

Heavy Oil Kromhout Engine (The Journal, March 1913, p. 527). See also Revue industrielle, vol. 44, no. 2083 18, p. 242, May 3, 1913.

Oddie-Simplex Steam-Air Pumps (The Journal, May 1913, p. 902). Cp. Die Turbine, no. 17, p. 309.

Water Hammer (The Journal, June 1913, p. 1057). Cp. The Practical Engineer (London), vol. 47, no. 1369, pp. 402, 403, 405, and The Practical Engineer, vol. 48, no. 1379, July 31, 1913, p. 111.

NECROLOGY

WALTER S. BROWN

Walter S. Brown, who was drowned while canoeing on the Lehigh Canal, July 13, 1913, was born in St. Louis, Mo., on December 30, 1871, and received his technical education in Washington University. From 1892 to 1902 he was connected with the St. Louis waterworks, first as draftsman, and then as assistant mechanical engineer in the construction and testing department. During part of this time he served as first lieutenant of the volunteer engineering regiment in the Spanish-American War, returning from Cuba after the war in command of his company.

In 1902 he removed to Bethlehem, Pa., to become engineer in the power department of the Bethlehem Steel Works, and held this position at the time of his death. Mr. Brown was a member of several masonic and benevolent orders.

WILLIAM MASON

William Mason who until his retirement from business a few years ago was master mechanic of the Winchester Repeating Arms Company, of New Haven, died in Worcester, Mass., on July 17, 1913. He was born in Oswego, N. Y., on January 30, 1837, and early showed his natural taste for mechanics. His training for his profession was obtained through apprenticeship as a patternmaker and machinist, his first connection being with the Remington Arms Company at Ilion, N. Y. After a long association with this company he resigned to enter the Colts patent firearms works at Hartford, and later the Winchester Arms Company.

Mr. Mason was the inventor of many appliances for looms and weaving, steam pumps, bridge work, and for arms and ammunition and the machinery connected with their manufacture, and also assisted in the design and construction of the Knowles steam pump and Knowles fancy looms. He was a member of the Union League Club, New Haven, and also of a number of scientific societies.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

Air Brake Association. Proc. 19th annual convention. *Boston, 1912.* Gift of the Society.

American Association of Demurrage Officers. Proc. 24th annual convention, 1913. Gift of association.

American Institute of Chemical Engineers. Trans. vol. 5, 1912. *New York, 1913.*

American Labor Legislation Review. Proc. 4th annual meeting. *New York, 1911.* Gift of the Society.

American Manufacturers' Export Association. Proc. 3d annual convention, 1912. *New York, 1912.* Gift of the Society.

American Mining Congress. Proc. 15th annual session, 1912. *Denver, 1913.* Gift of congress.

American Railway Bridge and Building Association. Proc. 22d annual convention. *Chicago, 1912.* Gift of the Society.

American Road Builders' Association. Proc. 8th annual convention. *New York, 1911.* Gift of the Society.

American Society of Inspectors of Plumbing and Sanitary Engineers. Proc. 1912. *Pittsburgh, 1913.* Gift of the Society.

The American Society of Mechanical Engineers. Journal, vol. 35, nos. 1-6, 1913. *New York, 1913.*

American Society of Municipal Improvements. Proc. 18th annual convention, 1911. *Milwaukee, 1911.* Gift of the Society.

Association for Standardizing Paving Specifications. 2d annual report, 1911. Gift of the Society.

Association of Car Lighting Engineers. Constitution. *Chicago, 1909.* Gift of the Society.

Association of Ontario Land Surveyors. Annual report, 1912. *Toronto, 1912.* Gift of the Society.

Der Bau der Wolkenkratzer. Otto Rappold. *München, 1913.*

Boston Metropolitan Water and Sewerage Board. Annual report, 1912. *Boston, 1913.* Gift of board.

Canadian Forestry Association. 11th annual report, 1910. *Quebec, 1910.* Gift of the Society.

——List of Members, 1910. *Ottawa, 1910.* Gift of the Society.

Canadian Railway Club. Proc. May 1912 meeting. *Montreal, 1912.* Gift of the Society.

Congreso Cientifico (1° Pan Americano). Derecho Internacional, constitucional e Historia. vol. 1, vol. 20. *Santiago de Chile,* 1912. Gift of congress.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS. Papers and Transactions for 1911. *New Haven, 1912.* Gift of the Society.

EISEN IM HOCHBAU. By Stahlwerks-Verband A-G. ed. 4. *Berlin, 1913.*

ELEMENTS OF HEAT-POWER ENGINEERING, C. F. Hirshfeld and W. N. Barnard. *New York, 1913.*

ENGINEERS AND ARCHITECTS CLUB OF LOUISVILLE. Constitution, By-Laws and List of Members. August 1, 1911. Gift of the Society.

ENGINEERS CLUB OF TORONTO. Proc. 1908-1909, vol. 1. *Toronto, 1909.* Gift of the Society.

EXCAVATING MACHINERY, A. B. McDaniel. *New York, 1913.*

HINTS ON SAFETY VALVES FOR STEAM BOILERS (Crosby). *Boston, 1913.*

HISTORY AND DEVELOPMENT OF SUBMARINE SIGNALS, H. J. W. Fay. Gift of Submarine Signal Company.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS. Proc. 28th annual meeting, 1913. *Milwaukee, 1913.* Gift of the Society.

IOWA ENGINEERING SOCIETY. Proc. 25th annual meeting. *Iowa City, 1913.* Gift of the Society.

IOWA STREET AND INTERURBAN RAILWAY ASSOCIATION. Proc. 9th annual convention, 1912. *1912.* Gift of the Society.

KANSAS CITY TESTING LABORATORY. Specifications and other information concerning asphalt and other materials used in paving. bull. no. 4. *Kansas City, 1913.* Gift of laboratory.

LAKES-TO-THE-GULF DEEP WATERWAY ASSOCIATION. 4th annual convention. *St. Louis, 1910.* Gift of the Society.

DER MENSCH UND DIE ERDE. vols. 8, 9. *Berlin.*

MODERN SCIENCE CLUB. Year Book 1908-1909. *Brooklyn, 1909.* Gift of the Society.

NATIONAL COMMERCIAL GAS ASSOCIATION. Proc. 8th annual convention, 1912. *New York.* Gift of association.

NATIONAL FIRE PROTECTION ASSOCIATION. Proc. 17th annual meeting, 1913. *Boston, 1913.* Gift of association.

NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION. Journal, January 20-24, 1913. *1913.* Gift of the Society.

NATIONAL SUPPLY AND MACHINERY DEALERS' ASSOCIATION. Proc. 7th annual convention. *1912.* Gift of the Society.

NATURAL GAS SERVICE, S. S. Wyer. *Columbus, 1913.* Gift of author.

NECROLOGIE. Victor Dwelshauvers-Dery. Liége. Gift of author.

NEW YORK (CITY) BOARD OF WATER SUPPLY. 5th annual report. *New York, 1910.* Gift of board.

NEW YORK (CITY) BOARD OF WATER SUPPLY. Report. Long Island sources. vols. 1-2. *New York, 1912.* Gift of board.

NEW YORK, NEW HAVEN AND HARTFORD RAILROAD COMPANY. General Statement. 1911, 1912. *New Haven, 1911-1912.* Gift of company.

NEW YORK SOCIETY OF ARCHITECTS. Year Book, 1911. *New York, 1911.* Gift of the Society.

POCKET-BOOK OF MECHANICS AND ENGINEERING, J. W. Nystrom. ed. 9. *Philadelphia, 1864.* Gift of Prof. Ira. H. Woolson.

POOR'S MANUAL OF PUBLIC UTILITIES, 1913. *New York, 1913.*

POOR'S MANUAL OF RAILROADS, 1913. *New York, 1913.*

PROBLEM OF SUBMARINE SIGNALLING. Extract from an article in National Magazine, October 1912. Gift of Submarine Signal Company.

RAILWAY STOREKEEPERS' ASSOCIATION. Report 9th annual meeting 1912. *1912.* Gift of the Society.

RAILWAY TELEGRAPH SUPERINTENDENTS. Proc. annual meeting 1912. *Milwaukee, 1912.* Gift of the Society.

SAFETY. W. H. Tolman and L. B. Kendall. *New York. 1913.*

ST. LOUIS PUBLIC LIBRARY. Annual report 1912-1913. *St. Louis. 1913.* Gift of library.

SCHIFFSTURBINEN. G. Bauer and O. Lasche. ed. 2. *München, 1913.*

SOCIETY OF CONSTRUCTORS OF FEDERAL BUILDINGS. bull., November 1912. *1912.* Gift of the Society.

SOCIETY OF ENGINEERS OF EASTERN NEW YORK. List of Members. July 15. 1911. Gift of the Society.

———Constitution and By-Laws. *Troy, 1904.* Gift of the Society.

SUBMARINE SIGNALS. *Boston, 1912.* Gift of Submarine Signal Company.

THERMODYNAMIK DER TURBOMASCHINEN. Guido Zerkowitz. *München-Berlin, 1913.*

UNIVERSITY OF NEVADA. *Register, 1912-1913. Reno, 1913.* Gift of university.

EXCHANGES

CANADIAN SOCIETY OF CIVIL ENGINEERS. Report of annual meeting, 1913, vol. 27. *1913.*

KONINK. INSTITUUT VAN INGENIEURS. Naamlijst der Leden, 1913. *1913.*

THE SHIPBUILDER. Annual international number, 1913. *Newcastle-upon-Tyne, 1913.*

UNITED ENGINEERING SOCIETY

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS CONVENTION. Structral steel poles and towers. R. Fleming. Gift of author.

CAMBRIA STEEL. Handbook of information relating to structural steel manufactured by the Cambria Steel Company. *Johnstown, 1912.* Gift of Cambria Steel Company.

CHRONOLOGY OF AVIATION. Hudson Maxim and W. J. Hammer. Reprinted from World Almanac. 1911. Gift of W. J. Hammer.

COLUMBIA UNIVERSITY. Catalogue of Officers and Graduates, 1754-1912. *New York, 1912.* Gift of university.

EFFICIENCY SOCIETY. Trans. vol. 1, 1912. *New York, 1913.* Gift of society.

INTERNATIONAL ACETYLENE ASSOCIATION. Report of 14th, 15th annual conventions. *Chicago. 1911-1912.* Gift of association.

MOODY'S MANUAL OF RAILROADS AND CORPORATION SECURITIES. vol. 2, 1913. *New York, 1913.*

QUEENS BOROUGH PUBLIC LIBRARY. Report of the chief librarian for the year ending December 31, 1912. *New York City, 1912.* Gift of library.

TRADE CATALOGUES

Chicago Pneumatic Tool Co., *Chicago, Ill.* Cat. no. 43, Rockford railway motor cars.

Clinton Wire Cloth Co., *Clinton, Mass.* Steel fabric, June 1913.

Foster Engineering Co., *Newark, N. J.* Cat. no. 20, valve specialities of the highest order, 1913.

Goldschmidt Thermit Co., *New York*, N. Y. Reactions, 2d quarter, 1913.

Greene, Tweed & Co., *New York*, N. Y. Rochester automatic lubricators.

Newall, G. M., Engineering Co., *Philadelphia, Pa.* The Ad-vance, July 1913.

North Western Expanded Metal Co., *Chicago, Ill.* Expanded metal construction, August 1913.

Sprague Electric Works, *New York*, N. Y. Bull. 246, motor driven exhaust fan outfits.

Under-feed Stoker Co. of America, *Chicago, Ill.* Publicity magazine, July 1913.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

714 Editor, aggressive, energetic young man of technical training, familiar with publishing business. Salary $25-$40 a week, depending upon experience. Location, New York.

721 Technical graduate for sales department. Prefer if possible a man who has had a few years' experience with engines or boilers. Good chance for advancement for the right man. Location, Indiana.

722 Designer and engineer having experience with four-valve engine design, construction and operation; 25-35 years of age. Salary $1500 to $1800. Location, New York State.

723 Partner, who can furnish necessary capital and who is successful salesman of boilers, to assist in development of a new water tube boiler of unique design, capable of good efficiency in all sizes from 100 h.p. upward; especially adapted to mill and blast furnace, central station and other operations requiring large units; some installations now operating in highly satisfactory manner. Ready for development on a large scale and now estimating on other installations.

724 Man with executive ability and good knowledge of building work of all kinds, both in steel, brick and reinforced concrete, versed in mechanical, electrical engineering and hydraulics.

725 Engineer to operate steam railroad, electric power plant, saw mill, logging machinery, etc. Location, North Carolina. Salary $250-$300.

726 New York concern desires to establish additional agencies in the following cities: Concord, N. H.; Burlington or Rutland, Vt.; Boston, Mass.; Springfield or Worcester, Mass.; Albany, N. Y.; Utica, N. Y.; Syracuse, N. Y.; Rochester, N. Y.; Trenton, N. J.; New Haven, Conn.; Hartford, Conn.; Harrisburg, Pa.; Scranton, Pa.; Providence, R. I.; Washington, D. C. These agencies could be handled by men representing other concerns.

801 Member, or member's son, with business ability and $10,000 can secure equal partnership with full financial control and management in new concern, to engage in the manufacture of a complete line of machinery fully covered by patents. Sales in the last three years, $100,000.

802 Large eastern university desires five instructors in mechanical engineering and mechanical engineering laboratory; three instructors in elec-

trical and electrical engineering laboratory and one instructor in drawing and design.

803 A man of experience and ability to organize a repair department of about 150 men; in charge of machinery in a plant employing about 800 men and representing an investment of between three and four million dollars. Salary $4000. Location Middle West. Apply through the Society.

804 Engineer with experience in heat, light and power work; 35 to 40 years of age. Salary $2500-$3000. Location, Philadelphia. Apply through the Society.

805 Instructor in mechanical engineering for one of the larger engineering institutions. Practical experience in the field. Salary $1300 for year of 12 months.

806 Instructor in machine shop practice wanted in western university school of engineering. Technical graduate preferred, but not required. Shop experience necessary. Will be required to instruct in modern shop methods, cost systems, standardized production, etc. Some time to be devoted to instrument making. Salary $1200 or more to man of wide experience.

MEN AVAILABLE

193 Sales engineer desires position where a knowledge of machinery and mill supply trade in United States and Canada is essential; seven years varied experience, nine years in selling end. Experience in correspondence and design of selling contracts.

194 Junior member, age 25, technical graduate, Columbia University, 1911, desires position either as assistant superintendent in factory, construction work, or in the heating and ventilating line. Broad experience as factory inspector.

195 Member, technical graduate, desires to secure position as assistant to consulting engineer or with manufacturing concern as mechanical engineer and efficiency expert. At present employed. Apply through the Society.

196 Young engineer, graduate Stevens Institute of Technology, experienced in electrical engineering in consulting engineer's office. Desires to change for prospect of advanced work in mechanical lines.

197 Member, age 31, married, well informed and of good address, desires change. Thorough operating and commercial experience. College trained. Assistant to executive, administrative or general sales officer preferred. Salary $3600.

198 Junior member, age 32, technical graduate in mechanical engineering, experienced in detailing, designing and estimating on steel plate work, familiar with boiler shop work, for last six years assistant manager, wishes a position with a company where such experience could be used.

199 Junior member, age 32, graduate in mechanical engineering, experienced in estimating and designing springs for heavy work and railroads, wishes position with a spring manufacturing company. Has also had extensive office experience as assistant manager in other lines.

200 Member, long experience on light and medium light weight manufacturing, desires position as works manager or general superintendent.

201 Member, 20 years varied experience in designing, building and

operating. At present in charge of large construction work nearing completion, also surface equipment of two mines and gravel plant on Pacific Coast. Has made special study of economical methods of handling materials. Accustomed to handling men, organizing crews, drawing up contracts, designing and purchasing; desires connection with some firm handling large work.

202 Junior member, age 29, extensive experience here and abroad in designing and operating by-product coke ovens, first-class organizer and expert furnaceman (Bunteschueler). Desires position as operating engineer or superintendent.

203 Member, master's degree from Cornell, desires position as electrical, mechanical or efficiency engineer, purchasing agent or manager of an industrial plant. Has had 20 years experience designing, constructing, operating and managing. Can give the best of references.

204 Junior member, age 26, technical graduate, at present connected with large hydroelectric project nearing completion, desires position in power or industrial plant design. Several years experience. References.

205 Student member, age 23, technical graduate with shop experience of a varied nature, has worked as draftsman and as designer; now assistant chief engineer in a boiler and engine concern of wide reputation. Salary depends upon opportunity. Reference can be given.

206 Mechanical engineer, technical graduate, age 35, with broad experience in central station work, designing, buying equipment, selling old material, supervision of installation, management of operation, in the construction and operating department; investigating requirements of large power consumers, estimating on cost to deliver service, management of isolated plants and the heating of buildings in the commercial department work. Desires position as manager or chief engineer. At present employed.

207 Member, 20 years experience in shop and office, last 5 years confidential aid to consulting engineer, having general charge of drafting room and design of railway and lighting power plants, special apparatus, etc., handling reports, specifications and correspondence, wants responsible position as engineer with operating company, manufacturing concern or consulting engineer.

208 Mechanical engineer, age 29, graduate Mass. Inst. of Tech., excellent experience in design of industrial plants and mechanical equipment of buildings, desires permanent connection with firm of consulting or mill engineers or position as plant engineer.

209 Member, age 38, technical graduate, desires position as assistant professor in an engineering school, preferably in the East. Eleven years practical experience, three years teaching and two years recent foreign study.

210 Mechanical engineer, techncal graduate, German, age 33, at present shop superintendent for Diesel motor construction, would like similar position in U. S. or Canada. Has 13 years experience.

211 Member, technical graduate, age 34, American, capable engineer, practical foundry and shop man, desires position as principal or assistant engineer, superintendent or manager. Broad engineering experience in

Europe and America as mechanic and executive in shop and plant construction, operation and maintenance, heavy machine building and light high grade manufacture. Salary commensurate with position.

212 Member, 31 years of age, at present employed, technical education, 10 years experience in design, construction, operation, maintenance and reorganization of mill, factory and other manufacturing properties. Wide experience in the superintendence of central power stations, factory extension, mill and reinforced concrete construction work.

213 Engineer, eight years experience in mechanical, electrical and construction work, desires a position leading to one of responsibility.

214 Member, age 54, has had charge of the design and equipment of the locomotive and car repair shops of three large railroads; also of power house work for trolley lines; for five years superintendent of bridges and buildings for a large eastern railroad.

215 Junior member; married, desires position as superintendent or business manager, preferably with an educational or medical institution. Seven years in present position as assistant manager of an important New York institution. Experienced in employing, organizing, purchasing, planning and supervision of building construction. Also five years of practical engineering experience. Salary dependent upon opportunity. Very best of references.

216 Graduate mechanical engineer, age 36, desires permanent position in or near New York. Excellent experience in engineering, purchasing and sales work with consulting, manufacturing and selling concerns. At present employed in executive sales position, but desires to change for better and more permanent work.

217 Factory manager or superintendent thoroughly familiar with modern machine shop practice, and production, capable of taking full charge of manufacturing plant, open for engagement after September 15.

218 Junior member, age 24, desires position as engineer, consulting or designing preferred. Experience mostly practical.

219 Member, graduate mechanical engineer, now employed, desires change; 15 years experience in design, construction and maintenance of power and heating plants, industrial plant equipment and cost estimating; also familiar with design and manufacture of automobiles, transmission and hoisting machinery; several years shop training. Chief designer factory engineer or superintendent; would also consider teaching position with large engineering school.

OFFICERS AND COUNCIL

President

W. F. M. Goss

Vice-Presidents

Terms expire 1913	Terms expire 1914
Wm. F. Durand	James Hartness
Ira N. Hollis	I. E. Moultrop
Thos. B. Stearns	H. G. Stott

Managers

Terms expire 1913	Terms expire 1914	Terms expire 1915
D. F. Crawford	Chas. J. Davidson	W. B. Jackson
Stanley G. Flagg, Jr.	Henry Hess	H. M. Leland
E. B. Katte	Geo. A. Orrok	Alfred Noble

Past-Presidents

Members of the Council for 1913

M. L. Holman
Jesse M. Smith
Alex. C. Humphreys
George Westinghouse
E. D. Meier

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

F. R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

W. F. M. Goss, *Chmn.*
Alex. C. Humphreys, *V-Chmn.*
E. B. Katte
E. D. Meier
Geo. A. Orrok
H. G. Stott

STANDING COMMITTEES

Finance

R. M. Dixon (1), *Chmn.*
W. H. Marshall (2)
H. L. Doherty (3)
W. L. Saunders (4)
W. D. Sargent (5)

Meetings

H. de B. Parsons (1), *Chmn.*
L. P. Alford (2)
H. E. Longwell (3)
H. L. Gantt (4)
R. H. Fernald (5)

Publication

G. I. Rockwood (1) *Chmn.*
G. M. Basford (2)
C. I. Earll (3)
I. E. Moultrop (4)
F. R. Low (5)

Membership

Hosea Webster (1), *Chmn.*
Theodore Stebbins (2)
W. H. Boehm (3)
H. C. Meyer, Jr. (4)
L. R. Pomeroy (5)

Library

L. Waldo (4), *Chmn.*
C. L. Clarke (1)
Alfred Noble (2)
W. M. McFarland (3)
The Secretary

Research

R. H. Rice (4), *Chmn.*
L. S. Marks (1)
A. L. De Leeuw (2)
R. C. Carpenter (3)
R. D. Mershon (5)

House

E. Van Winkle (1), *Chmn.*
H. R. Cobleigh (2)
S. D. Collett (3)
W. N. Dickinson (4)
F. A. Scheffler (5)

Public Relations

J. M. Dodge (3), *Chmn.*
J. W. Lieb, Jr. (1)
F. J. Miller (2)
W. R. Warner (4)
G. M. Brill (5)

SOCIETY REPRESENTATIVES

Engineering Education

A. C. Humphreys
F. W. Taylor

General Conference Committee of National Engineering Societies

C. W. Baker
E. D. Meier

Council of A. A. A. S

A. C. Humphreys
W. B. Jackson

John Fritz Medal

H. R. Towne (1)
J. A. Brashear (2)
F. R. Hutton (3)
J. R. Freeman (4)

Trustees U. E. S.

A. C. Humphreys (1)
F. J. Miller (2)
Jesse M. Smith (3)

SPECIAL COMMITTEES

Research Committee, Sub-Committee on Steam

R. H. Rice, *Chmn.*
C. J. Bacon
E. J. Berg
W. D. Ennis
L. S. Marks
J. F. M. Patitz

Power Tests

D. S. Jacobus, *Chmn.*
G. H. Barrus, *V-Chmn.*
E. T. Adams
L. P. Breckenridge
William Kent
E. F. Miller
Arthur West
A. C. Wood

Student Branches

F. R. Hutton, *Chmn.*
Wm. Kent
Geo. A. Orrok

Research Committee. Sub-Committee on Materials of Electrical Engineering

R. D. Mershon

Note—Numbers in parentheses indicate number of years the member has yet to serve.

Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for Care of Same in Service

J. A. Stevens, *Chmn.*
W. H. Boehm
R. C. Carpenter
Richard Hammond
C. L. Huston
H. C. Meinholtz
E. F. Miller

Tolerances in Screw Thread Fits

L. D. Burlingame, *Chmn.*
Elwood Burdsall
F. G. Coburn
F. H. Colvin
A. A. Fuller
James Hartness
H. M. Leland
W. R. Porter
F. O. Wells

Conference Committee on Engineering Standards

H. G. Stott, *Chmn.*
A. F. Ganz
Carl Schwartz

Society History

J. E. Sweet, *Chmn.*
F. R. Hutton, *Secy.*
H. H. Suplee

Committee on International Engineering Congress 1915

The President
The Secretary
W. F. Durand
R. S. Moore
T. W Ransom
C. R. Weymouth

Pipe Threads

E. M. Herr, *Chmn.*
W. J. Baldwin
G. M. Bond
S. G. Flagg, Jr.

L. V. Benet, *Paris Rep.*

Flanges

H. G. Stott, *Chmn.*
A. C. Ashton
A. R. Baylis
W. M. McFarland
Wm. Schwanhausser
J. P. Sparrow

Committee on Bureau of Information Respecting Engineering Standards in all Countries

Henry Hess, *Chmn.*
J. H. Barr
Charles Day
C. J. Davidson
Carl Schwartz

Research Committee. Sub-Committee on Safety Valves

P. G. Darling, *Chmn.*
H. D. Gordon
E. F. Miller
F. L. Pryor
F. M. Whyte

Committee on National Museum

E. D. Meier, *Chmn.*
G. F. Kunz
George Mesta
H. G. Reist
Ambrose Swasey

Standard Cross-Section Symbols

H. deB. Parsons, *Chmn.*
F. deR. Furman
A. E. Norton
Bradley Stoughton
John W. Upp

Changes in the Patent Laws of U. S.

W. H. Blauvelt
B. F. Wood
Carl Thomas
Edward Weston
W. E. Winship

Code of Ethics

C. W. Baker, *Chmn.*
C. T. Main
E. D. Meier
Spencer Miller
C. R. Richards

Refrigeration

D. S. Jacobus, *Chmn.*
P. De C. Ball
E. F. Miller
A. P. Trautwein
G. T. Voorhees

Involute Gears

Wilfred Lewis, *Chmn.*
Hugo Bilgram
E. R. Fellows
C. R. Gabriel
C. G. Lanza

Nominating Committee

J. R. Freeman, *Chmn.*
Chas. T. Main
Thos. Morrin
Fred. Sargent
C. C. Thomas

Conservation

G. F. Swain, *Chmn.*
C. W. Baker
L. D. Burlingame
M. L. Holman
Calvin W. Rice

Standardization of Filters

G. W. Fuller, *Chmn.*
Jas. C. Boyd
P. N. Engel
J. C. W. Greth
Wm. Schwanhausser

Standardization of Catalogues

Wm. Kent, *Chmn.*
J. R. Bibbins
M. L. Cooke
W. B. Snow

Chairmen of Sub-Committees of Committee on Increase of Membership

Boston, A. L. Williston
Buffalo, W. H. Carrier
Chicago, Fay Woodmansee
Cincinnati, J. T. Faig
Michigan, H. W. Alden
New York, J. A. Kinkead
Philadelphia, T. C. McBride
St. Louis, John Hunter
St. Paul, Max Toltz
San Francisco, Thomas Morrin
Seattle, R. M. Dyer
Troy, A. E. Cluett

Increase of Membership

I. E. Moultrop, *Chmn.*
F. H. Colvin
H. V. O. Coes
J. V. V. Colwell
R. M. Dixon
W. R. Dunn
J. P. Ilsley
E. B. Katte
R. B. Sheridan
H. Struckmann

SUB-COMMITTEES OF THE COMMITTEE ON MEETINGS

Cement Manufacture

J. G. Bergquist, *Chmn.*
H. J. Seaman, *V-Chmn.*
G. S. Brown
W. R. Dunn
F. W. Kelley
Morris Kind
F. H. Lewis
W. H. Mason
R. K. Meade
Ejnar Posselt
H. Struckmann
A. C. Tagge
P. H. Wilson

Machine Shop Practice

F. H. Colvin, *Chmn.*
E. P. Bullard
L. D. Burlingame
W. L. Clark
A. L. DeLeeuw
W. H. Diefendorf
F. L. Eberhardt
F. A. Errington
A. J. Fuller
H. D. Gordon
H. K. Hathaway
Alex. Kearney
Wm. Lodge
F. E. Rogers
N. E. Zusi

Textiles

C. T. Plunkett, *Chmn.*
E. W. Thomas, *Secy.*
D. M. Bates
John Eccles
E. D. France
E. F. Greene
F. W. Hobbs
C. R. Makepeace
C. H. Manning
H. F. Mansfield

Iron and Steel

Jos. Morgan, *Chmn.*
Thos. Towne, *Secy.*
W. P. Barba
F. F. Beall
Rogers Birnie
A. L. Colby
Julian Kennedy
M. T. Lothrop
W. E. Snyder
J. T. Wallis
R. M. Watt

Depreciation and Obsolescence

Alex. C. Humphreys, *Chmn.*
J. G. Bergquist
C. J. Davidson
A. E. Forstall
F. W. Kelley
H. Struckmann

Air Machinery

F. W. O'Neil, *Chmn.*
H. V. Conrad
William Prellwitz
R. H. Rice

Administration

J. M. Dodge, *Chmn.*
L. P. Alford, *Secy.*
D. M. Bates
John Calder
H. A. Evans
James Hartness
W. B. Tardy
Alexander Taylor
H. H. Vaughan

Industrial Building

F. A. Waldron, *Chmn.*
H. A. Burnham
Charles Day
William Dalton
J. O. DeWolf
C. T. Main

Railroads

E. B. Katte, *Chmn.*
G. M. Basford
W. G. Besler
A. H. Ehle
T. N. Ely
W. F. M. Goss
A. L. Humphreys
W. F. Kiesel
W. B. Potter
N. W. Storer
H. H. Vaughan
R. V. Wright

Fire Protection

J. R. Freeman, *Chmn.*
E. V. French, *V-Chmn.*
Albert Blauvelt
F. M. Griswold
H. F. J. Porter
T. W. Ransom
I. H. Woolson

Hoisting and Conveying

R. B. Sheridan, *Chmn.*
C. K. Baldwin
Alex. C. Brown
O. G. Dale
P. J. Fickinger
F. E. Hulett
Spencer Miller
A. L. Roberts
Harry Sawyer

GEOGRAPHICAL SECTIONS OF THE SOCIETY

Milwaukee

Fred H. Dorner, *Chmn*
M. A. Beck
Arthur Simon
Henry Weickel
E. P. Worden

Cincinnati

A. L. DeLeeuw, *Chmn.*
J. T. Faig, *Secy.*
W. G. Franz
G. W. Galbraith
L. H. Thullen

St. Louis

E. L. Ohle, *Chmn.*
F. E. Bausch, *Secy.*
F. N. Jewett
John Hunter
L. C. Nordmeyer

San Francisco

A. M. Hunt, *Chmn.*
T. W. Ransom, *Secy.*
W. F. Durand
E. C. Jones
Thos. Morrin

LOCAL MEETINGS OF THE SOCIETY

Boston

Henry Bartlett, *Chmn.*
R. E. Curtis, *Secy.*
H. N. Dawes
W. G. Snow
A. L. Williston

New York

F. A. Waldron, *Chmn.*
Edward Van Winkle, *Secy.*
R. V. Wright, *Treas.*
H. R. Cobleigh
J. J. Swan

Chicago

Paul P. Bird, *Chmn*
C. W. Naylor, *Secy.*
C. R. Birdsey
W. B. Jackson
A. W. Moseley

Philadelphia

A. C. Jackson, *Chmn.*
D. R. Yarnall, *Secy.*
J. E. Gibson
W. C. Kerr
T. C. McBride

New Haven

E. S. Cooley, *Chmn.*
E. H. Lockwood, *Secy.*
F. L. Bigelow
L. P. Breckenridge
H. B. Sargent

OFFICERS OF THE GAS POWER SECTION

Chairman

F. R. Hutton

Secretary

Geo. A. Orrok

Gas Power Executive Committee

C. H. Benjamin (1)
W. H. Blauvelt (3)
W. D. Ennis (5)
H. J. K. Freyn (1)
F. R. Low (2)
I. E. Moultrop (4)
H. H. Suplee (1)

Gas Power Literature Committee

R. B. Bloemeke, *Chmn.*
A. W. H. Griepe
W. F. Monaghan
W. S. Morrison
S. I. Oesterreicher
H. G. Wolfe

Gas Power Membership Committee

A. F. Stillman, *Chmn.*
H. V. O. Coes
J. H. Lawrence
F. S. King
J. H. Norris
G. M. S. Tait
J. D. Shaw
H. W. Anderson
C. D. Smith

Gas Power Committee on Meetings

Wm. T. Magruder, *Chmn.*
W. H. Blauvelt
E. D. Dreyfus
A. H. Goldingham
Nisbet Latta
H. B. MacFarland

OFFICERS OF AFFILIATED SOCIETY

Providence Association of Mechanical Engineers

T. M. Phetteplace, *Pres.*
J. A. Brooks, *Secy.*
W. H. Paine, *Vice-Pres.*
A. H. Whatley, *Treas.*

Note—Numbers in parentheses indicate number of years the member has yet to serve

OFFICERS OF THE STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN	CORRESPONDING SECRETARY
Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	H. E. Erickson	A. N. Koch
Case School of Applied Science	Feb 14, 1913	F. H. Vose	H. C. Mummert	C. Stemm
Columbia University	Nov. 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen
Cornell University	Dec. 4, 1908	R. C. Carpenter	J. G. Miller	Edw. Mendenhall
Lehigh University	June 2, 1911	P. B. de Schweinitz	W. C. Owen	T. G. Shaffer
Leland Stanford Jr. Univ.	Mar. 9, 1909	W. F. Durand	C. T. Keefer	K. J. Marshall
Mass. Inst. of Tech.	Nov. 9, 1909	E. F. Miller	W. H. Treat	L. L. Downing
New York University	Nov. 9, 1909	C. E. Houghton		
Ohio State University	Jan. 10, 1911	Wm. T. Magruder	R. H. Neilan	R. M. Powell
Penna. State College	Nov. 9, 1909	J. P. Jackson	H. L. Swift	H. L. Hughes
Poly. Inst. of Brooklyn	Mar. 9, 1909	W. D. Ennis	B. L. Huestis	A. Bielek
Purdue University	Mar. 9, 1909	G. A. Young	A. D. Meals	G. F. Lynde
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	E. Kneass	R. F. Fox
State Univ. of Iowa	Apr. 11, 1913	R. S. Wilbur	F. H. Guldner	C. S. Thompson
State Univ. of Kentucky	Jan. 10, 1911	F. P. Anderson	R. R. Taliaferro	F. J. Forsyth
Stevens Inst. of Tech.	Dec. 4, 1908	Alex. C. Humphreys	L. F. Bayer	C. H. Colvin
Syracuse University	Dec. 3, 1911	W. E. Ninde	O. W. Sanderson	R. A. Sherwood
Univ. of Arkansas	Apr. 12, 1910	B. N. Wilson	M. McGill	C. Bethel
Univ. of California	Feb. 13, 1912	Joseph N. LeConte	J. F. Ball	G. H. Hagar
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	A. O. Hurxthal	E. A. Oster
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	A. H. Aagaard	H. E. Austin
Univ. of Kansas	Mar. 9, 1909	F. W. Sibley	E. A. Van Houten	L. E. Knerr
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	E. H. Bigelow	O. H. Davis
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	W. P. Jesse	R. Runge
Univ. of Minnesota	May 12, 1913			
Univ. of Nebraska	Dec. 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh
Univ. of Wisconsin	Nov. 9, 1909	A. G. Christie	W. K. Fitch	J. W. Griswold
Washington University	Mar. 10, 1911	E. L. Ohle	D. Southerland	A. Schleiffarth
Yale University	Oct. 11, 1910	L. P. Breckenridge	C. E. Booth	O. D. Covell

Multi-stop and Double Turners

FIG. 1 illustrates the advantage of the *double stop* for each position of the turret, and the *double* adjustment of each turner. This piece has six finished diameters and six shoulders, and is turned by only three turners, which occupy only three positions on the turret. This not only leaves the remaining positions free for other tools, but it saves the operator the time and energy required to run the turret slide back each time.

All this is obtained without complication, and without introducing any features that are annoying when not in use.

In addition to the double stop for each of the six positions of the turret, we have an extra stop, consisting of a pin which may be dropped into any one of the six holes at the rear of the turret slide. This makes it possible to borrow five extra stops for any one of the tools, and gives to this tool seven length or shoulder stops, and leaves one stop for each of the remaining tools.

FIG. 1

The illustrations, Figs. 2 and 3, give examples of what one tool can do in this machine on chuck work, when we take advantage of the seven length stops and the seven shoulder stops of the cross-feed head.

Of course, in general practice three or four stops for one tool are all that will be needed, but since the modern cutting steels have greater durability, there is nothing lost by giving each tool all the work it can do.

Outer face and all shoulders and diameters accurately finished to independent stops by one tool. When roughing and finishing cuts are required, the roughing tool can be set near enough to use the same stops that are accurately set for the finishing tool. When an extra tool is used to give a roughing cut it is set as indicated by dotted lines in Figs. 2 and 3.

We find it difficult to illustrate all of the classes of work that can be turned out by this machine, but a little thought will suggest

HARTNESS FLAT TURRET LATHE

MAILED ON REQUEST

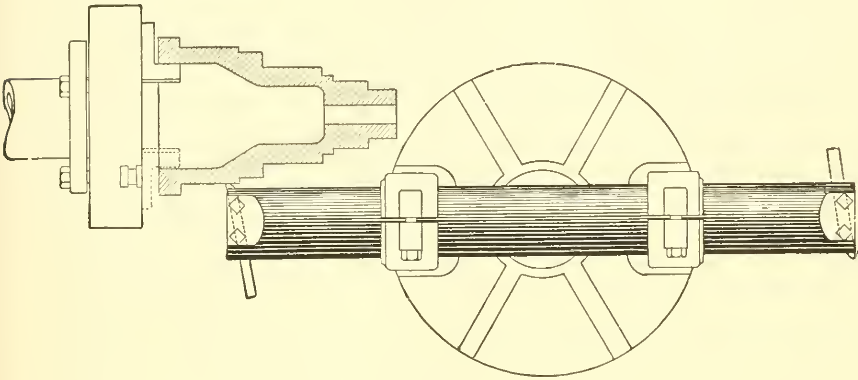


FIG 2

many forms that may be readily handled in bar and chucking work, both steel and iron, on account of the many provisions for bringing both turret and cross slide up to fixed stops; either by power feed or by hand.

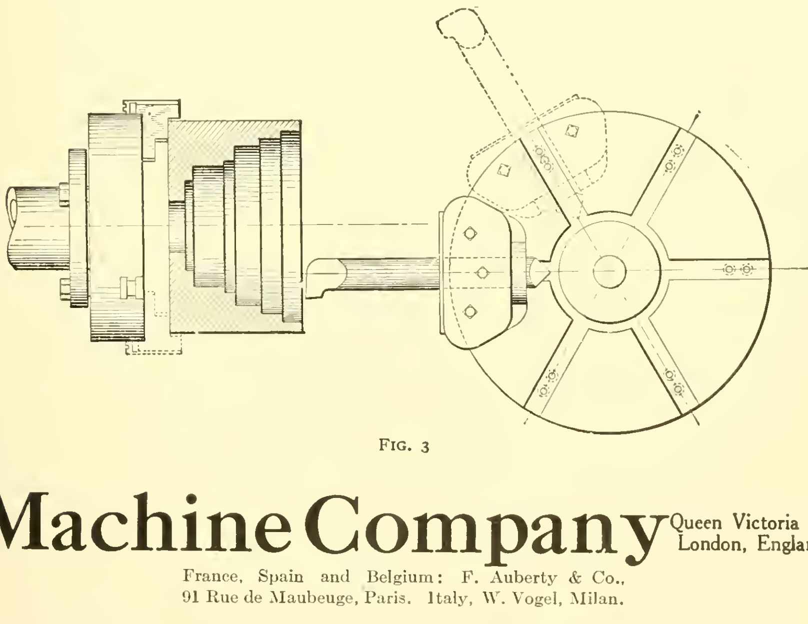
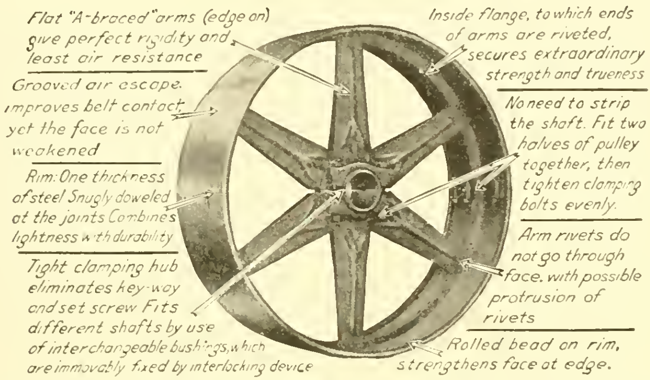


FIG. 3

A Double Belt Pulley—Proved by Actual Tests Lightest and Strongest



EVERY new size or style of "American" Pulley must undergo, in our testing room, a trial much more severe than it could meet under ordinary working conditions.

"American" Steel Split Pulleys

Perfect in Principle Powerful in Performance

are compared in our testing room, with corresponding sizes of other pulleys. If the "American" does not show up **better** than the others, it is **not good enough,** and the model must be improved.

In this way we have proved conclusively that "American" pulleys will stand up under greater strain than any other pulleys, even those having much more weight. Correctness of design makes the "American" true and balanced.

We have sold over 2,000,000 "American" Pulleys. Less than $\frac{2}{10}$ of one per cent. have been reported as failing to fulfill our guarantee of double belt service under any conditions, not requiring a special pulley.

Send for "Factors of Energy"—a booklet giving information and tables that every millman should have.

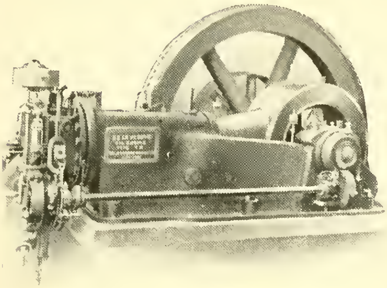
THE AMERICAN PULLEY COMPANY

OFFICE AND WORKS: PHILADELPHIA, PA.

Warehouses: New York, Grand & Greene Sts., Boston, 165 Pearl St., Chicago, 124 S. Clinton St.

Dealers Everywhere

DE LA VERGNE OIL ENGINES



show the highest thermal efficiency of any prime mover. In addition to this, they operate on the heaviest and cheapest grades of fuel oil, such as waste residual tars or asphaltic crude petroleum products which cannot be economically used in any other known way.

This, together with their remarkable high efficiency, makes the **De La Vergne Oil Engine the most economical prime mover on the market today.**

There are over **30,000** of the various types in successful operation.

As many as **eight successive orders comprising forty-two engines in all** have been placed by a single customer for his own use—proof positive of satisfactory service.

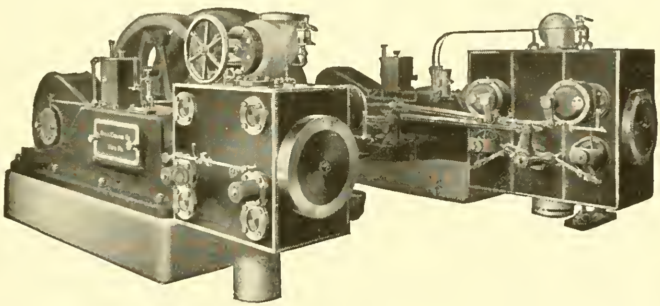
No special skill is required to operate them.

They are the ideal source of power for factory service, electric installations, pumping stations and isolated plants of every description.

Send for Bulletin No. 112.

DE LA VERGNE MACHINE CO.

1123 East 138th Street **New York City**



BALL CORLISS ENGINE

With Non-Detaching Valve Gear

It was the drop cut-off gear which made the Corliss Engine successful and economical for slow speeds.

The feature which distinguishes our High and Medium Speed Engines and makes them superior to all other four-valve engines is our *patented non-detaching valve gear.*

This gear by positive action gives the valves the *same movement* that the *drop cut-off* of the slow speed Corliss *produces* by picking up and dropping them.

The valve gear opens and closes the valves at the *proper* time, and holds the valves *absolutely still* during over *half a revolution.*

The valves are given the movement necessary for the *greatest durability* and *tightness*, and the *best form* of valve is made possible.

This engine marks the extreme limit of excellence so far reached in economy and quiet running.

BALL ENGINE CO., Erie, Penn.

MACHINE SHOP EQUIPMENT

FOUNDRY EQUIPMENT

BLOWERS, FANS, DRYERS, ETC.

ROLLING MILL MACHINERY

PUMPS AND HYDRAULIC TURBINES

PAPERS ON PUMPS AND HYDRAULIC TURBINES

PAPERS PUBLISHED BY A. S. M. E.

No. 381. Standard Method of Conducting Duty Trials of Pumping Engines: Committee Report, price $0.30; No. 1144. Balancing of Pumping Engines: A. S. Nagle, price $0.10; No. 1110. Development of Water-wheel Governor: M. A. Replogle, price $0.20; No. 1113. Turbine Design as Modified for Close Regulation: G. A. Bovinger, price $0.10.

STEAM ENGINES AND BOILERS

OIL AND GAS ENGINES AND GAS PRODUCERS

PAPERS ON OIL AND GAS ENGINES

PAPERS PUBLISHED BY A. S. M. E.

No 1336. Symposium on Oil Engines: H. R. Setz and F. M. Towl, Discussion, price $0.50; No. 1337. Design Constants for Small Gasolene Engines: W. D. Ennis, price $0.10; No. S41 X. A Regenerator Cycle for Gas Engines Using Subadiabatic Expansion: A. J. Frith, price $0.90; No. 1238. Marine Producer Gas Power: C. L. Straub, price $0.20.

POWER PLANT AUXILIARIES AND SPECIALTIES

PAPERS ON POWER PLANT SPECIALTIES

PAPERS PUBLISHED BY A. S. M. E.

No. 1085. Performance of a Superheater: A. Bement, price $0.10; No. 1070. A Twist Drill Dynamometer: H P. Fairfield, price $0.10; No. 921. The Bursting of Small Cast Iron Fly-Wheels: C. H. Benjamin, price $0.20; No. 1144. Balancing of Pumping Engines: A. F. Nagle, price $0.10.

STOKERS
PNEUMATIC ASH CONVEYORS

GREEN ENGINEERING CO.

Steger Building — CHICAGO, ILL.

Green Chain Grate Stokers for free burning and coking bituminous coals. GECO Pneumatic Ash Handling Systems.

See pages 50 and 51 of Condensed Catalogues of Mechanical Equipment.

FORCE FEED LUBRICATORS

GREENE, TWEED & CO.

109 Duane St. — NEW YORK

Rochester Automatic Force Feed Cylinder Lubricators, for the lubrication of all types of engines, pumps and air and ammonia compressors.

See page 159 of Condensed Catalogs of Mechanical Equipment.

LUBRICATION PUMPS

HILLS McCANNA COMPANY

153 W. Kinzie St. — CHICAGO, ILL.

Force Feed Lubrication Pumps made in any number of Feeds or Compartments.

VALVES

HOMESTEAD VALVE MANUFACTURING CO.

Works: HOMESTEAD, PA. — PITTSBURG, PA.

Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most difficult service for water, air or steam. Valves unlike all others.

VALVES
STEAM TRAPS
SEPARATORS
REGULATORS

THE HUGHSON STEAM SPECIALTY CO.

CHICAGO, ILL.

Manufacturers of Regulating Valves for all pressures and for steam, air and water. The best and only absolutely noiseless Combination Back Pressure and Relief Valve. Pump Regulators, Separators, Steam Traps, Automatic Stop and Check Valves. Write for complete catalogue.

AIR COMPRESSORS
AIR TOOLS AND HOISTS

INGERSOLL-RAND COMPANY

11 Broadway — NEW YORK

Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

VALVES
PACKING DISCS

JENKINS BROS.

NEW YORK — BOSTON — PHILADELPHIA — CHICAGO

Manufacturers of the genuine Jenkins Bros. Valves, made in brass, iron body, and cast steel, in a variety of types, suitable for moderate, medium or extra heavy pressures. Also a line of high grade mechanical rubber goods including sheet packing, gaskets, gasket tubing and pump valves. Illustrated catalogue sent on request.

PAPERS ON POWER PLANT SPECIALTIES

PAPERS PUBLISHED BY A. S. M. E.

No. 1288. Improved Absorption Dynamometer: C. M. Garland, price $0.10; No. 1287. Experimental Analysis of a Friction Clutch Coupling: W. T. Magruder, price $0.20; No. S 43 X. Automatic Control of Condensing Water: B. Viola, price $0.10; No. S 26 X. Air Leakage in Steam Condensers: T. C. McBride, price $0.20.

PAPERS PUBLISHED BY A. S. M. E.

No. S 107 X. The 1912 U. S. Standard Schedule of Standard Weight and Extra Heavy Flanged Fittings: Com-report, price $0.10; No. 1297. Transmission of Heat in Surface Condensation: G. A. Orrok, price $0.50; No. 1259. Cooling Towers for Steam and Gas Power Plants: J. R. Bibbins, price $0.40; No. 1072. Condensers for Steam Turbines: G. I. Rockwood, price $0.20.

PAPERS ON POWER PLANTS

HOISTING AND CONVEYING MACHINERY

AIR COMPRESSORS AND PNEUMATIC TOOLS

ELECTRICAL APPARATUS

POWER TRANSMISSION

ENGINEERING MISCELLANY

CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT

SECTION THREE

The various sections of the Condensed Catalogues published in The Journal during 1913 include Power Plant Equipment, Hoisting, Elevating and Conveying Machinery, Power Transmission Machinery, Industrial Railway Equipment, Electrical Equipment, Metal Working Machinery, Machine Shop and Foundry Equipment, Steel and Rolling Mill Equipment, Pumping Machinery, Mining and Metallurgical Equipment, Heating and Ventilating Apparatus, Refrigerating Machinery, Air Compressors and Pneumatic Tools, Engineering Miscellany.

At the close of the year the entire collection of Condensed Catalogues will be reprinted in volume form and distributed to 10,000 Mechanical Engineers, including the entire membership of the American Society of Mechanical Engineers.

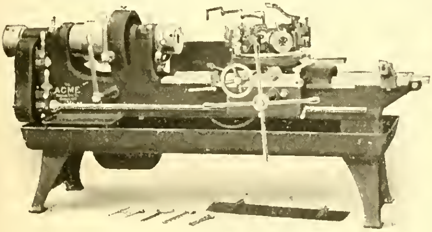
THE AMERICAN SOCIETY *of* MECHANICAL ENGINEERS

THE ACME MACHINE TOOL COMPANY

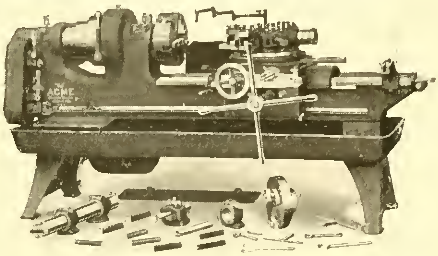
CINCINNATI, OHIO, U. S. A.

Code Word, ACME *Lieber's Code*

MANUFACTURERS OF THE ACME COMBINATION FLAT TURRET LATHE, THE CINCINNATI ACME TURRET SCREW MACHINES, TURRET LATHES, BRASS WORKING MACHINES AND UNIVERSAL TURRET LATHES AND ALL TOOLS AND ATTACHMENTS FOR THESE MACHINES.



2¼″ x 26″ C. F. T. L. with Bar Equipment

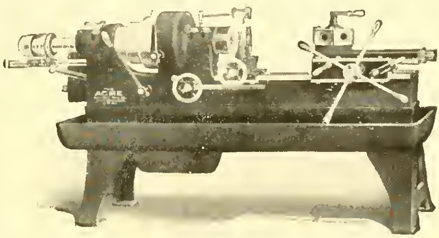


2¼″ x 26″ C. F. T. L. with Chucking Equipment

THE ACME COMBINATION FLAT TURRET LATHE

The double purpose machine; adapted to both bar and chucking work. Using simple, inexpensive tools. The greatest producer of work from bar stock, forgings and castings, accommodates bar stock up to 2¼″ dia. x 26″ long and forgings and castings 12″ diameter.

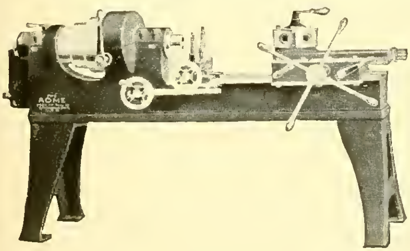
(SEND FOR SPECIAL BULLETINS)



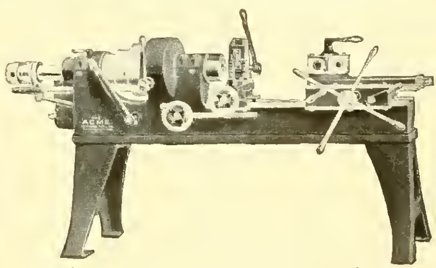
2¼″ x 11″ Screw Machine

TURRET SCREW MACHINES

Made in five sizes. Automatic chuck capacity ⅝″ to 2¼″, 11″ to 20″ swing. Plain or friction geared head with or without automatic feed to turret. Built to meet the demand for maximum production. Noted for their accuracy, rigidity, convenience to operator and many other superior features.



18″ Friction Geared Head Turret Lathe



18″ Turret Lathe with Forming Attachment

TURRET LATHES AND BRASS WORKING MACHINES

Made in four sizes, 14″ to 20″ swing. Plain or friction geared head, with or without automatic chuck, bar feed, automatic feed to turret, or cut off rest. Furnished with plain, set over or universal turret, also chasing attachment, forming attachment and all tools for rapid and accurate production.

Special tool equipment and estimates of production furnished on request.

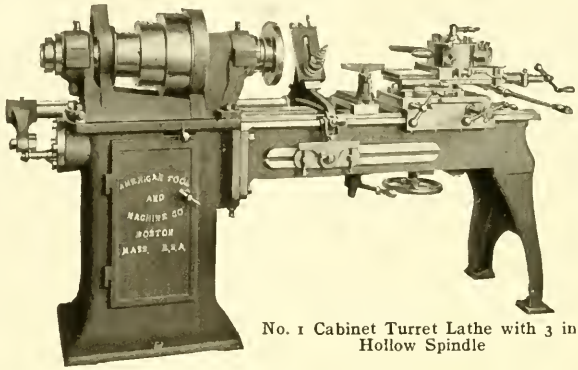
MACHINES OF QUALITY SEND FOR DETAILS

THE AMERICAN TOOL & MACHINE CO.

INCORPORATED 1864

BOSTON, MASSACHUSETTS, U. S. A.

LATHES, VALVE MILLING MACHINES, OIL SEPARATORS



No. 1 Cabinet Turret Lathe with 3 in. Hollow Spindle

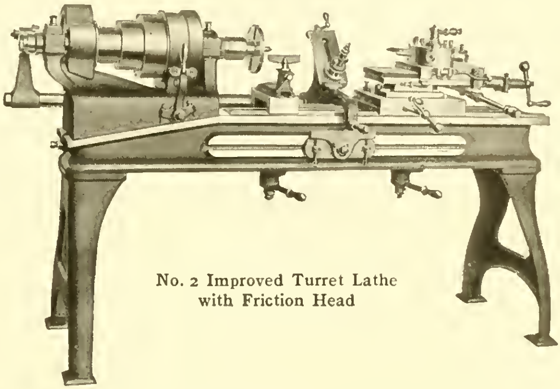
Turret Lathes (Nos. 00 and 0): Intended for heavy brass and iron work,.and rod work up to 2-in.•diameter. The forward motion of the turret can be accelerated by simply throwing the lever, and so is available instantly for either quick or slow operation.

Cabinet Turret Lathes (Nos. 1 and 2): These lathes are exceedingly compact and firm, without spring or chatter. Especially suited for general service on "Chucked work." Head stock swivelled for boring taper holes with power feed. No. 1 is also made with special 3-inch hollow spindle.

Catalog containing full description, illustrations and specifications of lathes, sent on request.

No.	Actual Swing.	Length of Bed.	Spindle.	Takes Between Centers.	Fitted with		
					Back Gears	Screw Apparatus	Taper Attachm't
TURRET LATHES.							
00	26⅜	8 ft.	2⅛" Hollow	46 in.			
0	24	8 ft.	Solid	46 in.	"	"	"
1	18	6 ft.	Solid	33 in.	"	"	"
CABINET TURRET LATHES.							
1	20½	7 ft.	Solid and 1⅝" Hollow	34 in.	"	"	"
1	20½	7 ft.	3" Hollow	34 in.	"	"	"
1 With Friction Head	20½	7 ft.	Solid	34 in.	"	"	"
2	18½	6 ft.	Solid	27 in.	"	"	"
IMPROVED TURRET LATHES.							
2	18½	6 ft.	1⅛" Hollow	34 in.	"	"	"
2 With Friction Head	18½	6 ft.	1⅛" Hollow	34 in.	"	"	"
IMPROVED LATHE.							
1	17	6 ft.	1⅛" Hollow	27 in.	"	"	"
SQUARE ARBOR LATHE.							
1	15	5' 6"	Solid	26 in.	"	"	......
2	13	5 ft.	Solid	27 in.	......	"	......
SET OVER AND BACK MOTION LATHES.							
2	13	5 ft.	Solid	27 in.	......	......	......
3	12¼	5 ft.	Solid	26 in.	......	......	......

THE AMERICAN TOOL & MACHINE CO.



No. 2 Improved Turret Lathe with Friction Head

Improved Turret Lathe: The headstock can readily be adjusted to a level with that of the tail stock. The hollow spindle has a thrust bearing that runs continuously in oil, thus relieving the spindle of friction and wear.

Headstock fitted with self-oiling, hard metal, bronze boxes with hardened steel thrust and take-up, washers and adjustable caps.

Tailstock fitted with swivelling arrangement and quick motion device to top slide.

Screw apparatus, Fox design with six point star follower, hob spindle revolves at half the speed of live spindle, insuring a strong and durable leading thread.

Friction Head: For work requiring widely different speeds in its several operations, a friction head, so called, has been designed. This combination enables the operator to use slow or back gear speeds by changing a lever.

OIL SEPARATORS

Belt Driven

Made in two sizes. No. 1 has a capacity of 520 cubic inches, and will separate in from five to eight minutes, the time being regulated by the condition and quality of the oil used.

These same conditions apply to the No. 2 or larger machine, which has a pan capacity of 2,540 cubic inches, and is proportionately heavier and stronger. The time required to separate with the No. 2 is practically the same as with the No. 1, provided both are running at the same peripheral speed. The No. 2 separator (see cut), having about five times the capacity of the No. 1, is better adapted to bulky, light-weight chips or turnings, but is equally effective on ordinary work.

Electrically Driven

The No. 1 separator is also mounted and geared for electric driving. Electric power is now in such general use for machine-shop work that this type of separator meets a demand from shops so equipped.

Direct Current Motors furnished for any voltage.

No. 2 Oil Separator

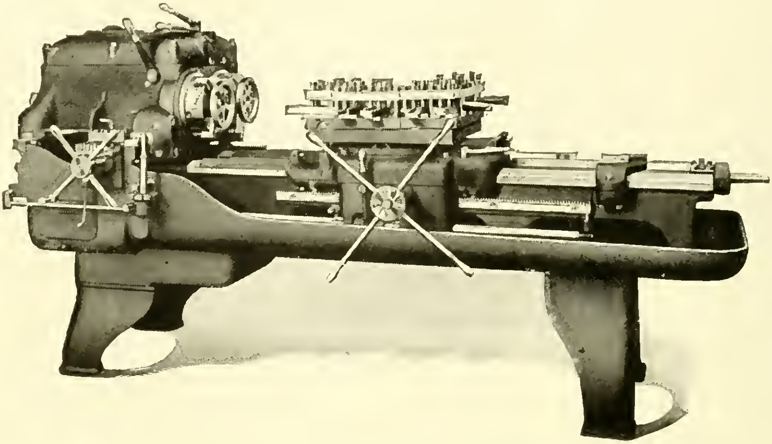
JONES & LAMSON MACHINE COMPANY

SPRINGFIELD, VERMONT, U. S. A.

77 Queen Victoria St., London, England

COST REDUCING MACHINES FOR LATHE WORK

THE DOUBLE SPINDLE FLAT TURRET LATHE



Double Spindle Flat Turret Lathe

The New Machine will be known as The Double Spindle Flat Turret Lathe. It is designed primarily for chuck work. It may be used either as a single spindle or a double spindle lathe. When used Single it can carry a chuck of 17-inch diameter, and when both spindles are used the two chucks are 9-inch diameter. This double spindle is another step toward highest output per dollar of investment. It possesses many unique features especially contrived to get out large lots of work. For small lots of work the single spindle lathe should be used, or this machine should be used, with one instead of two spindles.

The Two Spindle Machine gets it output by the use of two sets of tools. It carries on two similar cuts at the same time. Since these cuts are exactly the same, the speeds and feeds may be the most advantageous, the long cuts being taken on both pieces at the same time, and the short cuts are also taken simultaneously. This, of course, has a distinct advantage over the machines of multi-spindles in which one set of tools must operate on all of the pieces, for in such machines the total time is a multiple of the longest operation divided by the number of spindles, whereas in the present scheme the total time is only the sum of all the operations divided by two, the short one counting only for the exact time required instead of counting as much as the longest one.

The simplicity of operation and the similar character of the two cuts results in a greater saving than is apparent at first glance. It will be readily appreciated by those who have been exasperated by the excessive compromises that must be made in some instances in producing work on the multi-spindle turret machines in which only one set of tools is used. The loss of time on some kinds of work is a serious handicap, especially on work which requires a great difference in time in the performing of the several operations.

JONES & LAMSON MACHINE COMPANY

SPRINGFIELD, VERMONT, U. S. A.

77 Queen Victoria St., London, England

COST REDUCING MACHINES FOR LATHE WORK

THE DOUBLE SPINDLE FLAT TURRET LATHE

The advantages of the Double Spindle Flat Turret Lathe will be found to be many on many kinds of work, but of course it is designed more for manufacturing conditions of large repetition work than for conditions which call for quick change and small lots.

It gains its advantage over all other means not only on account of its double cuts of a kind, but **it combines with the double spindle the advantages that go with a hand-operated lathe,**—such as highest cutting speeds and feeds. These, of course, cannot be attained by an automatic machine that is not constantly under the watchful eye of the operator. The difference in speeds makes an important difference in output.

The Double Spindle Lathe also requires a little more care in setting the second set of tools so that they may act in harmony with the first set, but even this is minimized by the auxiliary adjustment provided for many of the tool holders; and another restriction is that with this doubling of tooling there is necessarily some restriction of the range of work, but it is nothing compared with the natural restrictions of other machines that are offered for manufacturing conditions. **Hence this machine and our Regular Single Spindle Lathe still maintain the leading position as adaptable broad range machines,** and these machines possess this desirable characteristic not by giving up their stability or convenience of control, but solely by well considered schemes of design, such as can only be brought forth by specialists.

For instance, let us look at the convenience of setting up the tools for turning a new piece of work on the Double Spindle. We will imagine we have a piece of chuck work about 8 inches in diameter, and, say about 4 inches wide, like a pulley, gear blank, or any similar piece which would require boring an inside hole, turning the outside diameter, facing the flange and hub, and perhaps turning the outside of the hub and inside of the flange and facing the web.

What is the most natural way to group these tools? What form of holding turret gives these tools the most stable support to resist the cutting stress? It seems to us that the most natural way to place these tools near the work previous to clamping them is to lay them down at the edge of a table with their cutting point projecting beyond that edge, just far enough to reach into or over the work, and that the best support for these tools would be such a table mounted solidly on a slide that will bring it up closely to the work so that there is no unnecessary overhang.

With such a thought in mind, we have given the Double Spindle Turret Lathe a square topped flat turret. The edges of its four sides may be presented one after the other to the work. Each edge may carry two sets of tools, the front set for the front spindle and the back set for the back spindle. These edges carry the tools which must have the most rigid and accurate support. (The four corners may be used for carrying drills, reamers, dies, taps or boring tools when working on one spindle at a time.)

Has there ever been presented a more ideal tool support for a Turret Lathe, both for meeting the most natural and convenient way of setting the tools for a new piece of work, and for the firmest control of these tools under working stress?

The means for clamping these tools to the top of the turret are the simplest, and, of course, the tools are likewise the simplest. Then, after that, the single slide scheme of operating reduces the uncertainty. For there is one handle that moves the turret carriage to and from the chuck, and another handle that moves the work-carrying headstock back and forth to get a change of diameter, and when either or both of these motions are made for one tool, we know that the other tool is similarly affected.

But we must go on with our story and give the second part of our announcement.

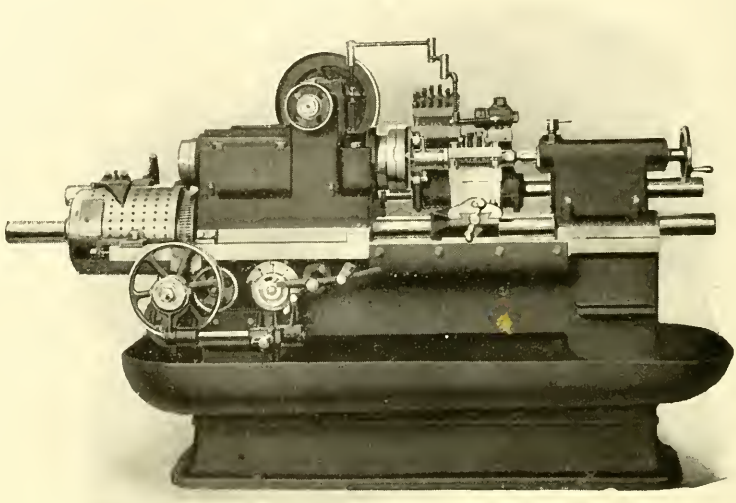
JONES & LAMSON MACHINE COMPANY

SPRINGFIELD, VERMONT, U. S. A.

77 Queen Victoria St., London, England

COST REDUCING MACHINES FOR LATHE WORK

THE FAY AUTOMATIC LATHE



The Fay Automatic Lathe

The Fay Automatic Lathe is now built and sold by the Jones & Lamson Machine Co. in conjunction with the Flat Turret Lathe.

The best industrialists know that it is not good practice to duplicate the number of handlings of a piece of work in the machine shop and we have won a great part of our good name by offering a way to do chucking work so that the whole piece comes from the machine fully turned. That is, in many cases; in fact, in most cases where the piece could be slightly remodeled to meet our conditions we have been able in the Flat Turret Lathe to bore, turn, face, and in fact, perform a variety of intricate lathe operations on a piece of work without ever taking it out of the chuck. In turning a gear blank, for example, we have turned the outside and both faces of the rim, we have faced the hubs and bored the hole perfectly true, all with one setting simply by holding the gear blank by chuck jaws that have gripped outwardly on the inner edge of the rim between the arms of the blank.

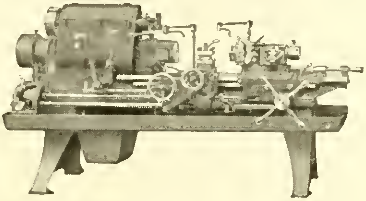
So many ways have been found to fully turn a piece of work at a single setting, or at least to turn all of those surfaces that should be absolutely true with each other, that a great saving in cost of such work has been effected by our machine. And it is a saving that every Superintendent of a machine shop appreciates, for he knows that it is almost impossible to re-chuck a piece of work so that it will run true with the cuts first taken. So difficult has this been that many sacrifices in design have been made just to provide a way to do all of the turning operations on a piece at one setting, thus ensuring absolute truth of the work.

THE WARNER & SWASEY COMPANY

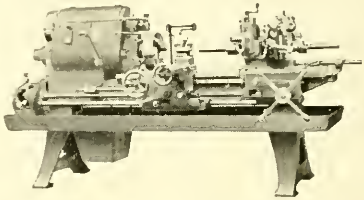
Works and Main Office: CLEVELAND, OHIO

Branch Offices: NEW YORK, BUFFALO, BOSTON DETROIT AND CHICAGO

TURRET LATHES TURRET SCREW MACHINES
BRASS-WORKING MACHINE TOOLS



No. 2A—Tools for Bar Work

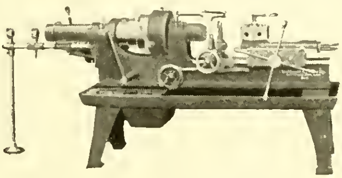


No. 2A—Tools for Chucking Work

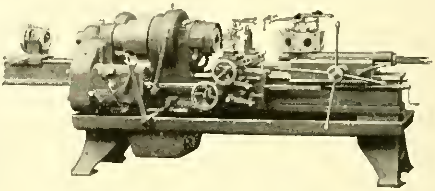
UNIVERSAL HOLLOW-HEXAGON TURRET LATHES

For the rapid, accurate and economical production of lathe work; from bar stock, forgings and castings. Complete tool equipments for bar and chucking work.

Two sizes: Automatic Chuck capacity, $2\frac{1}{4}$ and $3\frac{1}{4}$″; length turned, 26 and 36″; chuck swings, 12 and 15″.



No. 6—Bar Capacity $2\frac{1}{4}$″; Swing, 18″



No. 8—Bar Capacity $3\frac{5}{8}$″; Swing, 20″

TURRET SCREW MACHINES

Five sizes—$\frac{5}{8}$ to $3\frac{5}{8}$ automatic clutch capacity; 10 to 20″ swing.

With or without automatic chuck; bar feed; automatic feed for turret; automatic feed for cut-off, etc.—every modern facility for rapid production.

TURRET LATHES AND BRASS-WORKING MACHINE TOOLS

Turret Lathes—12 to 24″ swing; Plain, Set-over or Universal turret; with or without Geared-friction Head, Automatic Chuck; Cut-off; Forming attachment; Chasing attachment, etc.

Automatic Boring and Tapping Machines; Valve Milling Machines; Key Lathes; Cock Grinders, etc.—for the manufacture of valves, cocks, fittings and similar work.

Equipments planned and estimates of outputs furnished upon request.

T. C. DILL MACHINE COMPANY, INC.

PHILADELPHIA, PA., U. S. A.

BUILDERS OF SLOTTERS

THE "DILL SLOTTER"

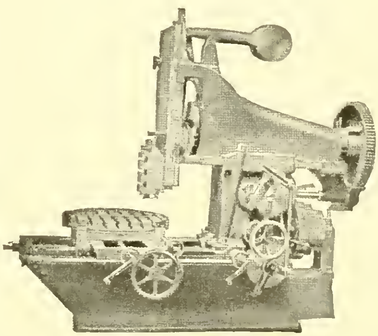
In the design of the "Dill Slotter," to meet the demands of to-day, it was plain that a departure was necessary and that procedure must be in at least two directions. First: that the machine must be able to produce a greater amount of work and that work must be more accurate. Second: that it must have a much greater range and not be confined only to the ordinary slotter work, but also reach out into other fields of usefulness; and, besides all this, it must be, if possible, more durable. The following features, which for the most part are exclusive, show how this Slotter meets the above requirements.

The GENERAL CONSTRUCTION of the "Dill Slotter" throughout is such as to insure efficiency and durability. It is constructed of the best material for the purpose; the gears are all cut from solid metal and mostly of forged steel; flat bearing surfaces are all hand-scraped to surface plates and are of ample dimensions. Gears, shafts, etc., are readily accessible for inspection. The convenience of operation is of special merit; while it is operative from one point principally, hand feeds are provided on all sides.

Attributes

A Traveling Head—Greatly increases the range of the machine.
A Quick Traverse Gear—A great time and labor saver.
New Quick Return—Permits high and uniform cutting speeds.
New Intermittent Feed—For feeding heavy work at high speeds
An Automatic Knock-Off—A safety device for the feed mechanism.
A Stroke Indicator—Quite indispensable; nothing like it.
A Hand Wheel Controller—A good thing, and in the right place.
A Tool Post in the Relief Apron Very handy in changing tools.
Six Changes of Speed—About four is the usual number.
Belt and Motor Driven—Designed for both; not a make-shift.
Powerfully Geared—About double the usual ratio.

15 Inch Slotter. Belt or Motor Driven



Arranged for Belt Drive

PRINCIPAL DIMENSIONS

Size of machine, ins.	10	10–12	15	15–18	20	20–24
Maximum stroke, ins.	10½	12½	15½	18½	21	25
Longitudinal movement of table, in.	28	28	36	36	48	48
Transverse movement of table, in.	20	20	30	30	40	40
Diameter of table, in.	24	24	34	34	44	44
Movement of head, in.	15	15	21	20	30	30
From table to head, in.	12	12	19¼	19¼	24½	24½
Adjustment of ram, in.	16	16	23	23	32	32
Will cut to the center of circle of	54 in.	54 in.	72 in.	72 in.	92 in.	92 in.
Will cut to outside of circle of	54 in.	54 in.	90 in.	90 in.	108 in.	108 in.
Strokes of ram per minute, r.p.m.	11½–85	10–76	8–48	7–43	6–31	5½ to 27
Feed of table per stroke, in.	0.011 to 0.154	0.011 to 0.154	0.010 to 0.187	0.010 to 0.187	0.0069 to 0.138	0.0069 to 0.138
Circular feed per stroke at 12 in. dia. (in.)	0.0187 to 0.261	0.0187 to 0.261	0.011 to 0.196	0.011 to 0.196	0.0055 to 0.11	0.0055 to 0.11
Feed of head per stroke, in.	0.0055 to 0.077	0.0055 to 0.077	0.005 to 0.093	0.005 to 0.093	0.00345 to 0.069	0.0345 to 0.069
Ratio of gears from cone pulley shaft	12 to 1	12 to 1	18 to 1	18 to 1	24 to 1	24 to 1
Size of countershaft pulleys, in.	14 x 3½	14 x 3½	20 x 4	20 x 4	26 x 5	26 x 5
Speed of countershaft, r.p.m.	200	180	200	180	200	180
Horsepower of motor	3	3	5	5	10	10
Speed of constant speed motor, r.p.m.	1,200	1,000	1.200	1,000	1,200	1,000
Speed of variable speed motor, r.p.m.	400 to 1,200	400 to 1,200	400 to 1,200	400 to 1,200	400 to 1,200	400 to 1.200
Net weight, lbs.	5,000	5,250	10,000	10,500	23,000	24,000

WINDSOR MACHINE COMPANY

WINDSOR, VERMONT, U. S. A.

FOREIGN OFFICE: 68 Ave. de la Grande Armeé, PARIS, FRANCE

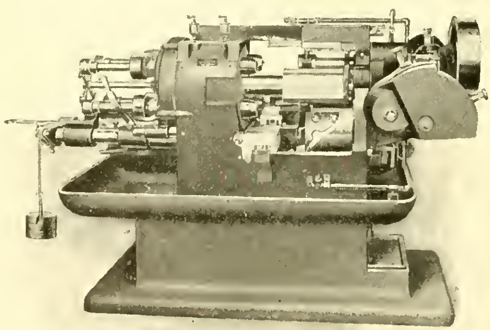
GRIDLEY AUTOMATICS

Increased output can be secured per day, week or month from GRIDLEY AUTOMATICS, because the rigidity of the tools and general design of the machine permit heavier cuts and coarser feeds to be obtained while the type of cutting tool used has a longer life.

Complex work that cannot be made on other automatics can be easily done on Gridleys, for there is room on the tool slide to attach accessories to tools that cannot be used on other machines.

GRIDLEY MULTIPLE SPINDLE AUTOMATICS

have four spindles, a single belt constant speed drive and a quick-change-gear feed box. They are made in three sizes with a maximum capacity for bars of ¾″, 1¼″ and 2¼″ respectively, the ¾″ machine finishing work up to and including 4½″ in length, the 1¼″ up to and including 5½″ and the 2¼″ up to and including 7″.



Gridley Multiple Spindle Automatic

One finished piece of work results each time the tool slide moves forward.

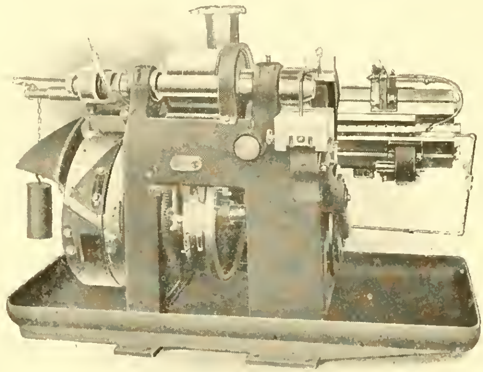
The tool slide being mounted on the stem of the Spindle Carrier insures perfect alignment of all tools with the spindles.

WINDSOR MACHINE COMPANY

GRIDLEY AUTOMATIC TURRET LATHE
(Single Spindle)

These machines are built in three sizes, viz., 2¼", 3¼" and 4¼", with a capacity for handling bars not larger in diameter than their respective sizes imply and turning up to 12" in length.

The tools used on the Gridley Automatic Turret Lathe are different from those used on all other automatics, better results being obtained at a small cost for maintenance. As they are supported close to the cutting edge and held without overhang, rapid and accurate work will be produced at all times.

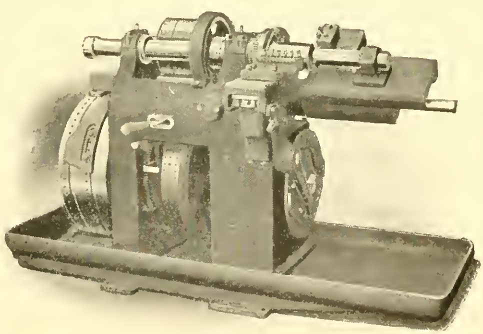


Gridley Automatic Turret Lathe (Single Spindle

GRIDLEY PISTON AND RING MACHINE

This is a semi-automatic, especially designed for making pistons and eccentric piston rings used in gas engines.

The largest ring this machine will handle is 6 inches in diameter. Smaller rings, down to those used in motorcycle engines, can be made as the proper spindle speed can be secured.



Gridley Piston and Ring Machine

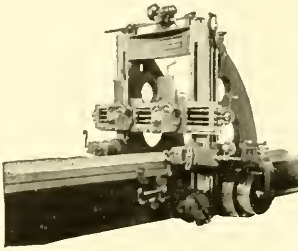
Pistons are made to advantage on these machines.

The Piston and Ring Machine is built on the same general lines as the Gridley Automatic Turret Lathe and has the same features of work and feed control.

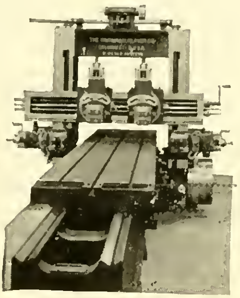
THE CINCINNATI PLANER CO.

CINCINNATI, OHIO

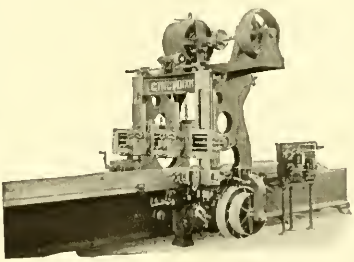
METAL PLANERS



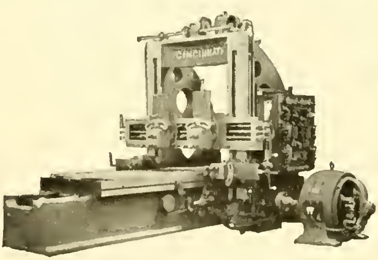
Standard Planer



Widened Planer



Electric Variable Speed Planer



Reversible Motor Driven Planer

CINCINNATI STANDARD PLANERS

Cincinnati Standard Planers are designed for strength, rigidity, durability, convenience in operation, and adaptability for all classes of work required of a planer.

THE BEDS are of a heavy deep box section of great width through the body, and are especially strengthened where the gearing and uprights are mounted. The length has been increased, being now one and two thirds longer than the table.

THE TABLES are of unusual thickness and are braced at short intervals with heavy ribs, thus preventing any possibility of springing under any circumstances.

CROSS RAILS are of great depth, and have an extra deep box brace on the back to give additional stiffness, and are accurately scraped to straight edges and surface plates.

THE HEADS are distinctive, the ends of tool blocks and slides being made round to avoid projecting corners on angular work. They are carefully scraped to the rail, and are graduated for swivelling up to ninety degrees. They have automatic feeds in all directions, and can be operated from either side of the machine. The saddles being right and left, the tools can be run very close together.

MICROMETER ADJUSTMENT is furnished on all down feed screws. This consists of a collar graduated into thousandths, and will be found a great convenience for obtaining certain depths of cut rapidly and accurately.

THE GEARING AND RACK are of extra wide face, and are accurately cut from the solid by a system of special cutters for each gear. This gives a smooth running machine capable of producing the most accurate work, and insuring great strength and long wear. All the large gears and racks are made from semi-steel castings, and the pinions from steel forgings. All gearing is thoroughly covered for protection from chips and dirt.

CINCINNATI WIDENED PLANERS

There is a great variety of planing which does not require a standard machine, and manufacturers are rapidly recognizing the advantage of widened planers. It is not always advisable to buy a 48" x 48" Standard Planer simply because your work is 48" wide. In many cases a 36" planer widened to 48" will do the work better, as it is easier to handle and capable of higher speeds. We build these planers to suit your work, and have patterns for the various sizes given below.

Sizes—34" x 24", 36" x 30", 42" x 36", 48" x 36",
56" x 42", 60" x 48", 72" x 56", 96" x 72".

CINCINNATI VARIABLE SPEED PLANERS

The greatest possible gain in planing comes from access to a change of cutting speeds. A correct speed for all materials and conditions, instantly available, is the secret of economy, in planing. A planer operating at a speed of 20 ft. cut and 80 ft. return makes 960 cutting ft. per hour, at 40 ft. cut and 80 ft. return it makes 1600 cutting ft. per hour, a gain of nearly 70 per cent. Our variable speed planers are arranged for ten cutting speeds and ten return speeds.

CINCINNATI MOTOR DRIVEN PLANERS

All Cincinnati Planers may be arranged for motor drive. Motors may be of either direct current or alternating current type.

THE DETRICK & HARVEY MACHINE CO.

BALTIMORE, MD.

MANUFACTURERS OF THE OPEN SIDE PLANERS; HORIZONTAL, BORING, DRILLING AND MILLING MACHINES; SPECIAL MACHINERY.

THE OPEN SIDE PLANER

This term, used by this Company and its predecessors, Detrick & Harvey, for the past 25 years, actually describes the novel and patented construction in contradistinction from metal planers of the ordinary two-post type. These planers are offered as equal to the ordinary type in the performance of the regular line of work, and in capacity and adaptability as excelling any other metal planing tool.

The Open Side Planer takes work under the beam slightly larger than the rated vertical dimension, and squares down the outside of work to the rated width. It actually planes, by angling the beam head, several inches wider on a straight surface.

Sizes and Capacity

Size	Will Plane Wide, Ins.	Will Plane High, Ins.	Length, Feet
30 Inch	40	31	6, 8, 10, 12, 14
36 Inch	50	37	8, 10, 12, 14, 16
42 Inch	58	43	10, 12, 14, 16, 18
48 Inch	62	49	12, 14, 16, 18, 20
60 Inch	75	61	14, 16, 18, 20, 22
72 Inch	91	73	16, 18, 20, 22, 24

THE CONVERTIBLE OPEN SIDE PLANER

is designed to cover a wide range of planing work and is the equal of a double housing planer of the same rated capacity, embodying the use of four tools. Through the removal of the outer housing or post, the machine is converted into an Open Side Planer, and the wide range and great adaptability peculiar thereto is obtained. The Convertible Open Side Machines are built in sizes 42 inches to 96 inches square, by any length.

THE OPEN SIDE EXTENSION PLANER

This type differs from the standard Open Side Planer in that it has an outside post and long beam. This outside post is adjustable in an extension bed to and from the Planer platen. It will be especially noted that both side heads can be used simultaneously in a wide range of work, varying in size from the width of the table to the full rated width of the Planer, while the long beam gives a corresponding range of travel to the horizontal heads.

These machines are made in the following sizes:

To plane 84 inches by 60 inches high by 12, 14, 16, 18 or 20 feet if desired.

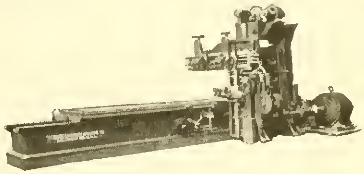
To plane 96 inches wide by 72 inches high by 14, 16, 18, 20 or 22 feet, or longer, if desired.

To plane 120 inches wide by 96 inches high by 16, 18, 20, 22 or 24 feet, or longer, if desired.

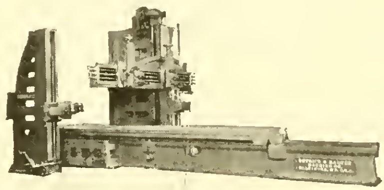
To plane 120 inches wide by 120 inches high by 24 feet, or longer, if desired.

HORIZONTAL DRILLING, BORING AND MILLING MACHINES

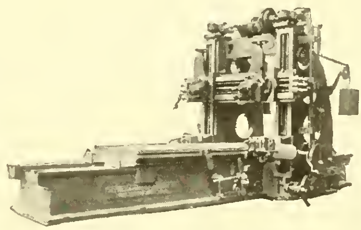
These machines are commonly known as Floor Boring Machines and consist principally of a Column mounted on a Runway, a Spindle-Saddle mounted on the Column and a Work Bed. Can be equipped with Outer Support, Universal Table, Plain Table, Scales and Pump.



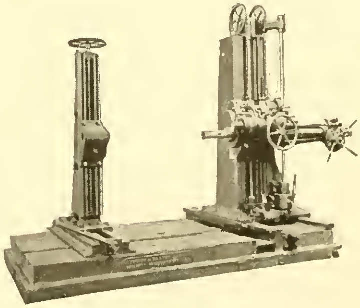
Motor Driven Open Side Planer



Convertible Open Side Planer, Showing Outer Housing Removed Converting the Machine into an Open Side Planer



Standard Double Housing Planer

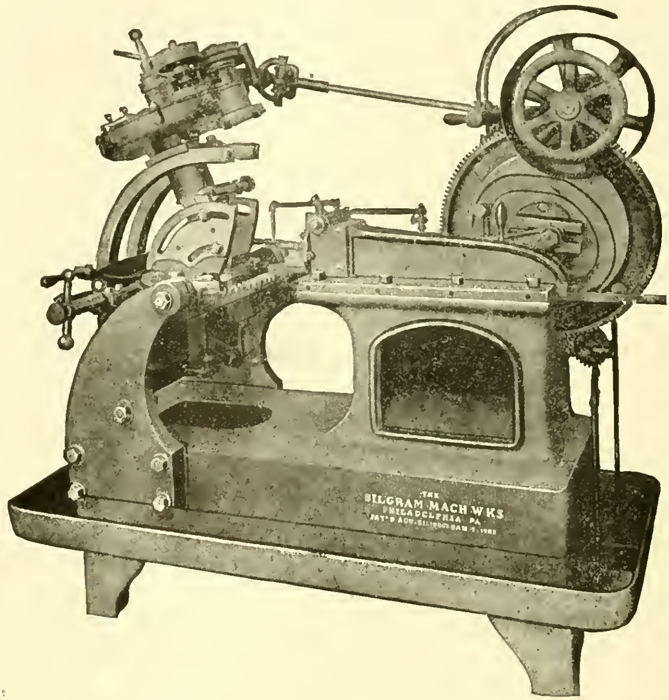


Horizontal Drilling, Boring and Milling Machine

THE BILGRAM MACHINE WORKS

1217 SPRING GARDEN ST. PHILADELPHIA, PA.

MAKERS OF SPECIAL MACHINERY
BEVEL GEARS CUT THEORETICALLY CORRECT
SPECIAL FACILITIES FOR CUTTING SPUR, WORM, SPIRAL AND INTERNAL GEAR WHEELS



THE BILGRAM BEVEL GEAR GENERATOR

SIX INCH TYPE

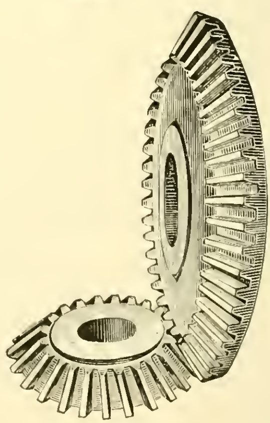
Planes bevel wheels up to 6 in. diameter, 1 in. pitch, $2\frac{1}{2}$ face, from miter wheels to bevel wheels of proportion one to six.

Floor Space................3 ft. 10 in. x 2 ft. 3 in.
Net weight of machine..................2000 lbs.
Net weight of countershaft, cone sectors, etc.............................. 400 lbs.
Gross weight..........................2800 lbs.

SIXTEEN INCH TYPE

Planes bevel wheels up to 16 in. diameter, 2 in. pitch, 6 in. face from miter wheels to bevel wheels of proportion one to four.

Floor space.................6 ft. 1 in. x 2 ft. 8 in.
Net weight of machine..................4800 lbs.
Net weight of machine, countershaft, cone sectors, etc........................ 800 lbs.
Gross weight..........................6100 lbs.



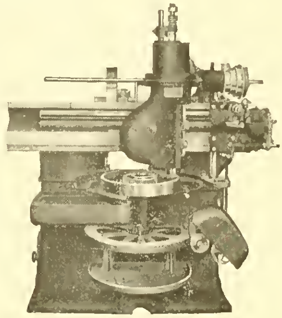
THE FELLOWS GEAR SHAPER CO.

SPRINGFIELD, VERMONT, U. S. A.

MANUFACTURERS OF THE FELLOWS GEAR SHAPER AND GEAR SHAPER CUTTERS

THE FELLOWS GEAR SHAPER

The Gear Shaper is a gear generator, developing the gear tooth by a planing process. The cutter used is an original gear which is ground after it is hardened.



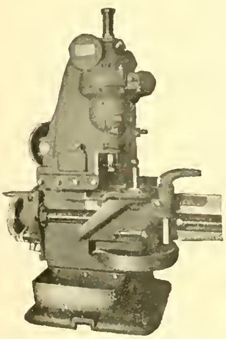
No. 6 Gear Shaper
Planing Internal Gear

Action of the Gear Shaper

After fastening the blank to the work arbor, the machine is started and the cutter moves up and down in true shaper style. The cutter is then fed toward the blank and cuts its way to the proper depth. The feed of the cutter is produced by a slow rotation of the cutter and the blank in unison. The combined result of rotary and reciprocatory motions is that the cutter teeth generate conjugate teeth in the blanks which mesh correctly with the cutter teeth and with each other. Any two gears of the same pitch cut with this cutter mesh correctly together.

Distinctive Features

1. The Gear Shaper cuts a theoretically correct gear tooth. Because the tooth curve of the cutter is ground after it is hardened, the cutter and work cut by it approach nearer to absolute perfection than anything else produced in this line.



No. 3 Gear Shaper
Front View

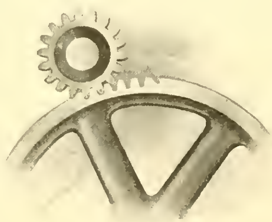
2. Only one cutter for each pitch is necessary. The investment in cutters is reduced very largely.
3. It will cut more gears than any other machine.
4. An error in spacing is an impossibility.
5. No depth gauge is required; the machine attends to that automatically.
6. The work is held by the "face plate system."
7. It cannot produce an incorrect form of tooth by setting the cutter "off the center."
8. The cutter travels practically the face of the blank only, whereas the milling cutter must travel from 10 to 40 per cent more.
9. A variation in diameter of blank or depth of cut does not produce noisily running gears.
10. It will plane internal gears.
11. Center distances can be exactly duplicated.
12. It will plane into a narrow recess.
13. Gear teeth cut upon this machine give the full theoretical bearing.

Capacity

The No. 3 Gear Shaper cuts external spur gears of 24 inches diameter, 4 inches face, 6 diametrical pitch in cast iron, 7 pitch in steel. The No. 6 machine cuts external spur gears of 35 inches diameter, 5 inches face, 4 diametrical pitch, and internal spur gears of 28 inches pitch diameter, 3 inches face, 4 diametrical pitch.

THE GEAR SHAPER CUTTER

The Fellows Gear Shaper Cutter has teeth in which the involute curve is generated by rolling the cutter tooth past an emery wheel in true rack and pinion movement, the cutter representing the pinion and the emery wheel one side of a rack tooth. This makes every cutter an original gear with generated teeth, and as this grinding is done *after the cutter is hardened*, it insures accurate work at all times.



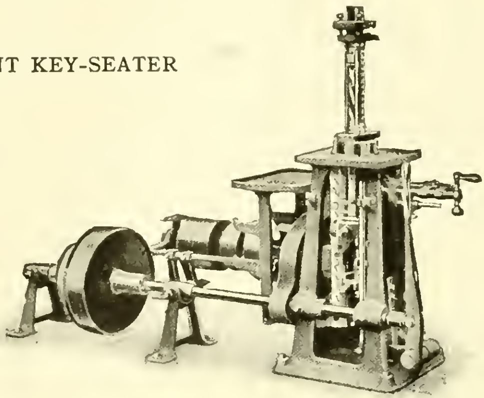
The Gear Shaper Cutter
and a Partially Cut Blank

MITTS & MERRILL

SAGINAW, MICHIGAN

MANUFACTURERS OF THE GIANT KEY-SEATER, KEY-SEAT MILLING MACHINES, AND BORING MILLS

THE GIANT KEY-SEATER



No. 2 Giant Key-Seater and Countershaft.

THE GIANT KEY-SEATER cuts perfectly true. Key-ways straight or tapered without regard to whether the hub is faced true or left rough as it comes from the foundry. Every job is quickly and accurately set and fastened by *its bore only.*

This means that in many cases it is possible to save the expense of facing a hub by using the Giant Key-Seater. The saving in money represented by this feature alone will soon pay for the machine.

A key-seat 6″ long, ½″ wide, and ¼″ deep can be cut in two minutes. This includes time of putting on and taking from machine.

The machines may be fitted to cut Key-seats in holes from ½ inch in diameter up to the largest size needed, and it is possible for the largest machine to operate in very small and long holes. In key-seating small work such as steel milling cutters ½ inch thick, eighteen or more pieces can be cut at one time. No other machine does this.

We can furnish cutters for special work, such as square holes, half-round key-seats, dovetail key-seats, double key-seats, or other special shapes such as are used in automobile work.

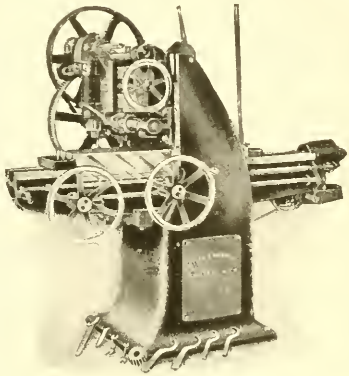
The Giant will finish two ordinary key-seats before one piece can be fastened, ready for key-seating on other styles of machines.

FLOOR SPACE, WEIGHT AND OTHER DATA

Key-seater	Stroke	Largest Post that may be used	Widest Cutter that may be used	Approx. Gross Weight	Floor Space
No. 0	7 inch	1½ inch	¾ inch	650 lbs.	2 x 3 ft.
No. 2	13 inch	2⅜ inch	1¼ inch	1500 lbs.	5 x 2 ft.
No. 3	16 inch	3⅜ inch	2 inch	1900 lbs.	5½ x 2 ft.
No. 3A	25 inch	3⅜ inch	2 inch	2000 lbs.	5½ x 2 ft.
No. 4	19 inch	3 11/16 inch	2½ inch	2100 lbs.	6 x 2 ft.
No. 5	25 inch	4⅞ inch	3 inch	4300 lbs.	6½ x 3 ft.
No. 6	31 inch	6 inch	4 inch	4800 lbs.	6½ x 3 ft.
No. 6A	38 inch	6 inch	4 inch	4800 lbs.	6½ x 3 ft.

MITTS & MERRILL
SAGINAW, MICH.

KEY-SEAT MILLING MACHINE

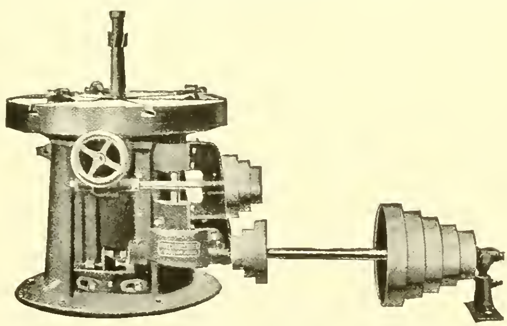


No. 3 Key-Seat Milling Machine
For 1 inch to 10 inch shafts.

Our No. 3 Key-Seat Milling Machine is equipped with a vertical arbor for routing out the ends of key-seats. The machine is strongly geared and stiffly built for key-seating shafts up to 10″ in diameter, and for ordinary plain milling up to capacity of the machine. The hand wheels for the different feeds and movements of the machine are conveniently arranged and the weight of the crossrail and gearing is counterbalanced. The platen has basins on each end to catch the lubricant for which the rail serves as a reservoir. The vertical and cross feed have micrometers for fine adjustment. With the machine is furnished wrenches and an adjustable floor stand for shafting. Two smaller sizes are made as listed below. The No. 1 machine is only suitable for milling key-seats in shafting. Nos. 2 and 3 will do for plain milling also.

Machine	Capacity	Table	Traverse	Floor Space Req.	Weight
No. 1	¾ in. to 3 in. dia. shaft	12 long	14	34 x 22	800 lbs.
No. 2	1 in. to 6 in. dia. shaft	26 x 12	34	36″ x 31 or 40	2800 lbs.
No. 3	1 in. to 10 in. dia. shaft	44 x 12½	43	74 x 36	4100 lbs.

BORING MILL



For Straight or Taper Holes up to 8 in. Diameter

We illustrate a Boring Mill which we manufacture and have used in our own shop for several years. It is designed for boring a class of duplicate or heavy work difficult to chuck in a lathe, and for the occasional job of large diameter. Driving shaft and pulley can be extended any distance required to swing the work on revolving table. Cutter bar is clamped in a saddle sliding on a vertical rail which is pivoted at the top and can be swung from the perpendicular to bore holes up to 2 inch taper per foot or more if required.

Capacity: will bore holes up to 8 inches diameter and 18 inches long.

Table: 35 inches diameter, 5 inches deep; has 6 T slots for $\frac{7}{8}$ inch bolts. Height of table above floor, 33 inches. Bearing for table is a $7\frac{1}{2}°$ x 45° V bearing 3 inches wide, 18 inches diameter.

Vertical rail, 2 feet 9 inches long, 10 inches wide.

Saddle has bearing 14 inches long and a travel of 18 inches. Saddle holds boring bars up to $2\frac{15}{16}$ inches diameter.

Floor space, 3 feet 6 inches by 6 feet 6 inches. Weight 2300 lbs.

LANDIS TOOL COMPANY

WAYNESBORO, PA.

PRECISION CYLINDRICAL GRINDING MACHINES

Our regular line consists of the following types and sizes:

UNIVERSAL MACHINES No. 1 (10″x20″); No. 1½ (10″x30″); No. 2 (12″x32″); No. 3 (12″x42″); No. 4 (12″x66″). Nos. 2, 3 and 4 are also built with 16″-swing, and are used for finishing tools and a variety of straight or taper parts, both external and internal, such as are common to the toolroom, machine shop, railroad shops, etc.

Attachments, such as magnetic chuck, gear-cutter attachment, side mill grinding attachment, etc., can be used on these machines to advantage.

PLAIN GRINDING MACHINES; 10″x20″, 10″x30″, 12″x32″, 12″x42″, 12″x66″ 16″x66, 12″x96″, 12″x120″, 16″x72″, 20″x96″, 20″x120″, 20″x144″, 20″x168″. These strictly manufacturing machines are intended for finishing straight and taper spindles, shafts, rolls, tubing and all other work within their range which can be revolved on dead centers.

PLAIN GRINDING MACHINES WITH GAP are our 16″ and 20″ swing. Plain Machines, built with gap in the bed to suit the location of the projection on the work. Especially valuable for grinding locomotive piston rods.

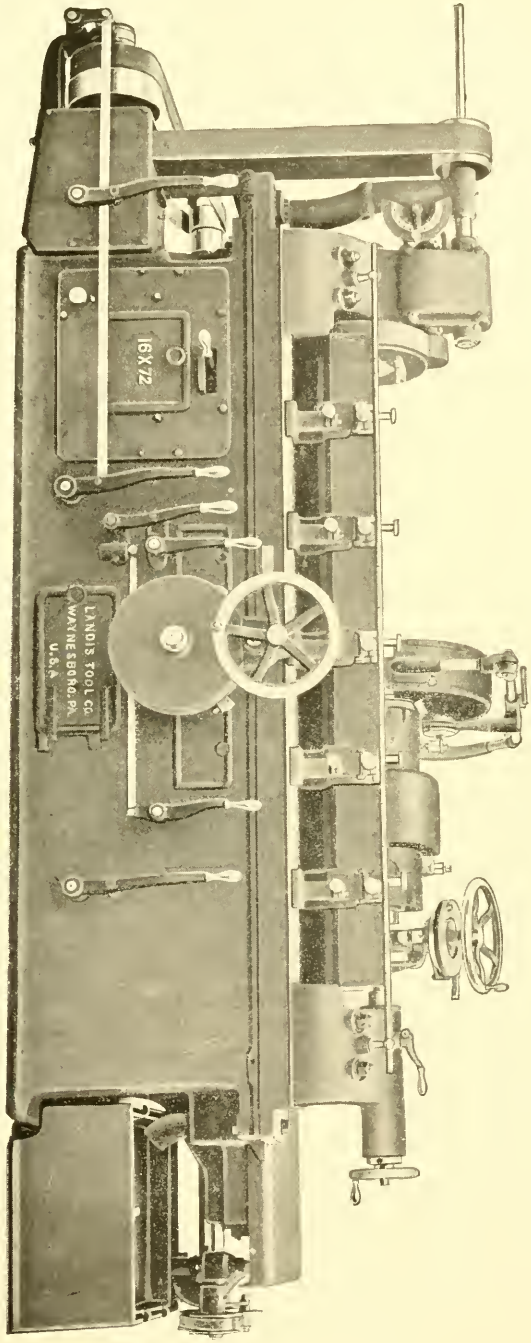
INTERNAL GRINDING MACHINE for straight and taper internal grinding, and the fixtures for these machines will grind holes ¼″ diameter, or larger, and up to 12″ long.

CRANK GRINDING MACHINE for grinding single or multiple throw crank shafts used in gas and small steam engines.

ROLL GRINDING MACHINES for grinding chilled iron and hardened steel rolls.

CAM GRINDING ATTACHMENTS for grinding cams are for use on our plain and universal grinders and are made for grinding either detachable or integral cams.

Our illustrated and descriptive catalogue and literature gives detailed information. It also describes the features which stand for quick manipulation, accurately finished work, durability of alignments and rapid production—all of which are prominent in the various types of Landis Grinding Machines.



Landis Self-Contained Plain Grinding Machine

THE GEOMETRIC TOOL COMPANY

NEW HAVEN, CONN.

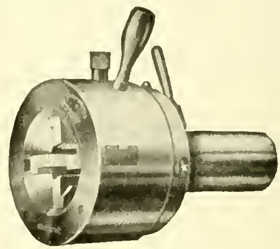
MANUFACTURERS OF SPECIAL MACHINERY AND TOOLS

SPECIAL THREADING TOOLS

In the manufacture of small parts, the demand for rapid and economical production, combined with higher standards of accuracy, has caused old methods of threading to be almost entirely discarded. To meet this demand the Geometric Special Threading Tools were placed on the market a number of years ago and have since been developed to a point where they are unequalled for accuracy and economy.

GEOMETRIC SCREW-CUTTING DIE-HEAD

Self-opening and Adjustable



Style "D" Die-Head with Roughing Attachment

In the Geometric Die-head, the dies are opened automatically by simply stopping the travel of the turret slide when the desired length of thread is reached. Four or more accurately hobbed chasers or dies, of carbon or high-speed steel, carried in a substantial head, are used according to the diameter of the work. All Die-heads are equipped with micrometer scales by means of which a tight or loose fitting thread may be cut, also making it possible to compensate for wear of the dies. The saving thus effected through the greatly increased possible output and elimination of waste material through defective pieces, will soon far exceed in value the difference in the initial cost of a Geometric Die-head as compared with a solid die.

Style "D"—This type is designed for use on the turret of hand and automatic screw machines, in place of solid dies. A roughing and finishing attachment forms part of this style in sizes over and including ¾ inch.

Style "C"—This style embraces special types for threading automobile parts, plumbers' supplies, bicycle parts, brass and iron fittings and for cutting standard iron pipe threads.

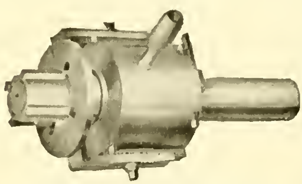
Style "DD" is especially designed for use in the turret of the Cleveland or similar automatic screw machines. The Die-head is supported by a spring mechanism between the head and the shank, which permits the chasers to compensate for any inaccuracy of adjustment of the turret.

Solid Adjustable

The Geometric Solid Adjustable Die-head is a special form of Die-head designed for use on automatic screw machines where the direction of rotation of the piece is reversed on the completion of the thread. The chasers are of the standard Geometric form and are interchangeable with those employed in the Styles "D" and "DD" Die-heads.

GEOMETRIC ADJUSTABLE COLLAPSING TAPS.

Where work of one inch or greater diameter has to be tapped, the advantages of Geometric Collapsible Taps are so numerous as to place them in a class entirely by themselves. They automatically collapse when the required depth has been reached, and can be instantly withdrawn without running back over the threads. Can be used on a live spindle, such as a drill press, as well as on a screw machine or turret lathe.



Class "N-L" Tap Equipped with Chasers for Bottoming

Class "N-L" Collapsing Tap is furnished to cut pipe threads from ¾ to 12 inches in diameter inclusive. It may also be furnished for tapping other classes of work up to a maximum diameter of 12¾ inches, and either in the plug or bottoming type.

Class "P" Taps are designed solely for tapping fine pitch threads of short depth. They can be furnished for cutting diameters from ¾ inch up to 10 inches inclusive.

THE GEOMETRIC TOOL COMPANY

SPECIFICATIONS AND PRICES

Style "D" Self-Opening and Adjustable Screw-Cutting Die-Heads

Size, Ins.	Diam. of Head, Ins.	Length of Head, Ins.	Diam. of Shank, Ins. *	Length of Shank, Ins.	Length Over All, Inches	Capacity, Inches	Coarsest Pitch of Thread	Greatest Length will Cut, Ins.	Price, including One Set of Dies for One Standard Pitch Thread	Extra Dies per set, Carbon Steel	Extra Dies per set, H. S. Steel	Blank Dies per set, Carbon Steel	Code Word
5/16	1 3/4	1 3/8	5/8 or 3/4	1 3/4	3 1/8	3/32 to 5/16	18	Any l'g'th when standard shank is used	$25.00	$1.50	$2.25	$0.75	Pitch
9/16	2 7/16	2 1/16	7/8 or 1	2 1/2	4 9/16	1/8 to 9/16	12		30.00	1.75	2.63	.90	Past
3/4	2 15/16	2 13/16	1 1/4 or 1 1/2	3	5 13/16	1/4 to 3/4	10		40.00	2.00	3.00	1.00	Push
1	3 9/16	3 1/4	1 1/2 or 1 3/4	3 1/2	6 3/4	3/8 to 1	8		50.00	2.50	3.75	1.25	Pull
1 1/4	4 15/16	4	1 3/4 or 2	4 1/4	8 1/4	1/2 to 1 1/4	7		65.00	3.00	4.50	1.50	Pale
1 1/2	5 5/16	4 3/4	2 1/4 or 2 3/4	4 3/4	9 1/2	5/8 to 1 1/2	6		80.00	3.50	5.25	1.75	Part
2	6 3/8	5 1/4	3 or 3 1/2	5 1/4	10 1/2	3/4 to 2	4 1/2		95.00	4.00	6.00	2.00	Punt
2 1/2	6 7/8	5 3/8	3 1/2 or 4	5 7/8	11 1/4	1 to 2 1/2	4		135.00	5.00	7.50	2.50	Pet
3	7 1/2	6 1/8	4 or 4 5/8	6 1/2	12 5/8	1 1/2 to 3	3 1/2		175.00	6.00	9.00	3.00	Pilf
3 1/2	8 1/2	7	4 1/2 or 5 1/2	7	14	2 to 3 1/2	3 1/4		215.00	7.00	10.50	3.50	Pick
4 1/2	11	8 1/8	6 or 7 1/2	10	18 1/8	2 1/2 to 4 1/2	2 3/4		275.00	10.00	15.00	5.00	Pike

Style "DD," Model 1911, Self-Opening and Adjustable Screw-Cutting Die-Heads

Size, Ins.	Diam. of Head, Ins.	Length of Head, Ins.	Diam. of Shank, Ins. *	Length of Shank, Ins.	Length Over All, Inches	Capacity, Inches	Coarsest Pitch of Thread	Greatest Length will Cut, Ins.	Price, including One Set of Dies for One Standard Pitch Thread	Extra Dies per set, Carbon Steel	Extra Dies per set, H. S. Steel	Blank Dies per set, Carbon Steel	Code Word
5/16	1 3/4	2 1/4	5/8 to 1 1/4	5	7 1/4	1/16 to 5/16	18	2	$30.00	$1.50	$2.25	......	Olam
9/16	2 7/16	2 15/16	5/8 to 1 7/8	5	7 15/16	1/8 to 9/16	12	3	35.00	1.75	2.63	......	Oak
3/4	2 15/16	3 3/8	5/8 to 1 7/8	5	8 3/8	1/4 to 3/4	10	3 1/2	45.00	2.00	3.00	......	Otis
1	3 9/16	1 3/16	7/8 to 2 1/2	5	9 3/16	3/8 to 1	8	4	55.00	2.50	3.75	......	Opal
1 1/4	4 7/16	4 9/16	1 to 3 1/4	6	10 9/16	1/2 to 1 1/4	7	4 1/2	70.00	3.00	4.50	......	Ode

Solid Adjustable Screw-Cutting Die-Heads

Size, Ins.		Capacity, Inches	Coarsest Pitch of Thread	Greatest Length will Cut, Ins.	Price, including One Set of Dies for One Standard Pitch Thread	Extra Dies per set, Carbon Steel	Extra Dies per set, H. S. Steel	Blank Dies per set, Carbon Steel	Code Word
5/16	Fitted with Plain Shank......	3/32 to 5/16	18	Depending on shank used	$15.00	$1.50	$2.25	$0.75	......
	Fitted with Releasing Holder..				17.50				
	Fitted with Gridley Holder....				20.00				
9/16	Fitted with Plain Shank.......	1/8 to 9/16	12		20.00	1.75	2.63	.90	......
	Fitted with Releasing Holder..				22.50				
	Fitted with Gridley Holder....				25.00				
3/4	Fitted with Plain Shank.......	1/4 to 3/4	10		25.00	2.00	3.00	1.00	......
	Fitted with Releasing Holder..				27.50				......
	Fitted with Gridley Holder....				30.00				
1	Fitted with Plain Shank.......	3/8 to 1	8		35.00	2.50	3.75	1.25	......
	Fitted with Releasing Holder..				37.50				
	Fitted with Gridley Holder ..				40.00				

Class "NL" Collapsing and Adjustable Pipe Taps

Size, Ins.	Largest Diameter of Head, Ins.	Length of Head	Diameter of Shank, Ins. *	Length of Shank, Ins.	Morse Taper Shank	Length Over All, Ins.	Capacity, Standard Pipe Sizes, Ins.	Capacity, Straight Thread, Ins.	Greatest Depth, Straight Tapping, Ins.	Coarsest Thr'ds per In.	Price, including One Set of Carbon Steel Chasers	Extra Chasers per Set, Carbon Steel	High Speed Steel	No. of Chasers per Set
3/4	2 5/16	4 1/16	5/8 to 7/8	2 1/2	No. 2	6 13/16	3/4	15/16 to 1 1/8	1 1/8	14	$40.00	$3.25	$4.88	4
1	3 1/4	5 5/8	1 to 1 3/8	4 3/4	Nos. 3 or 4	10 3/8	1	1 1/8 to 1 3/8	1 1/2	11	45.00	3.25	4.88	4
1 1/4	3 1/4	5 3/4	1 to 1 3/8	4 3/4	Nos. 3 or 4	10 1/2	1 1/4	1 3/8 to 1 3/4	1 5/8	11	50.00	3.25	4.88	4
1 1/2	3 13/16	6 1/4	1 1/8 to 1 5/8	4 3/4	No. 4	11	1 1/2	1 5/8 to 2 1/8	1 3/4	11	55.00	3.50	5.25	4
2	3 13/16	6 3/8	1 1/8 to 1 5/8	4 3/4	No. 4	11 1/8	2	2 1/8 to 2 3/4	1 7/8	11	60.00	3.50	5.25	4
2 1/2	4 7/8	7	1 1/2 to 2 3/8	4 3/4	Nos. 4 or 5	11 3/4	2 1/2	2 1/2 to 3 1/4	2	8	65.00	4.50	6.75	6
3	5 1/4	7 1/8	1 5/8 to 2 3/8	5	No. 5	12 1/8	3	3 1/8 to 4	2 1/8	8	70.00	5.00	7.50	6
3 1/2	5 5/8	7 1/8	1 5/8 to 2 3/8	5	No. 5	12 1/8	3 1/2 & 4	3 5/8 to 4 5/8	2 1/8	8	75.00	5.00	7.50	6
4	6 1/2	8 5/16	1 5/8 to 3 1/8	5	Nos. 5 or 6	13 5/16	4 & 4 1/2	4 1/8 to 5 1/4	2 1/2	8	80.00	5.50	8.25	6
4 1/2	7	8 5/16	1 5/8 to 3 1/8	5	Nos. 5 or 6	13 5/16	4 1/2 & 5	4 5/8 to 5 7/8	2 1/2	8	85.00	5.50	8.25	6
5	7 1/2	9 5/16	1 3/4 to 3 7/8	5 1/2	Nos. 5 or 6	14 13/16	5 & 6	5 1/4 to 6 5/8	2 3/4	8	90.00	6.00	9.00	6
6	8 1/2	9 5/16	1 3/4 to 3 7/8	5 1/2	Nos. 5 or 6	14 13/16	6 & 7	6 1/4 to 7 3/4	2 3/4	8	100.00	6.00	9.00	6
7	9 1/2	9 5/16	1 3/4 to 3 7/8	5 1/2	Nos. 5 or 6	14 13/16	7 & 8	7 1/4 to 8 7/8	2 3/4	8	125.00	6.50	9.75	6
8	11 1/4	9 11/16	2 to 4 1/2	6	No. 6	15 11/16	8 & 9	8 1/4 to 10	3	8	150.00	8.00	12.00	8
9	12 1/4	9 11/16	2 to 4 1/2	6	No. 6	15 11/16	9 & 10	9 1/4 to 11 1/4	3	8	175.00	8.00	12.00	8
10	13 1/4	9 11/16	2 to 4 1/2	6	No. 6	15 11/16	10 to 12	10 1/4 to 12 3/4	3	8	200.00	10.00	15.00	10

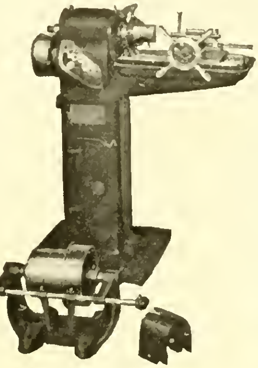
* Shanks of special diameter and length can be furnished where required.

(Continued on next page)

(Continued from preceding pages)

THE GEOMETRIC TOOL COMPANY

GEOMETRIC THREADING MACHINE



Will produce accurate work in quantity and should not be confused with the usual run of bolt-threading machines. The machine is regularly equipped with a standard style "D" Die-head modified to meet the changed requirements of operation and with a range from $\frac{1}{4}$ to $\frac{3}{4}$ inches. Can be fitted for cutting standard screw threads up to and including 3–4″—10 pitch. A larger Die-head equips the machine for threading brass tubing and similar work up to 2″ diameter, where the thread is not coarser than 22 pitch.

Speeds of machine spindle when countershaft is run at speed of 225 RPM.

Gear Box	$\frac{1}{4}$″	$\frac{5}{16}$″	$\frac{3}{8}$″	$\frac{7}{16}$″	$\frac{1}{2}$″	$\frac{5}{8}$″	$\frac{3}{4}$″
Speeds	225	180	150	128	112	100	90

COUNTERSHAFT

Driving Pulley	$8\frac{1}{2}$″ x $2\frac{3}{4}$″
Tight and Loose	7″ x $2\frac{3}{4}$″
Speed	225 RPM.
Net weight of Machine	394 lbs.
Net weight of Countershaft	92 lbs.
Gross weight	567 lbs.

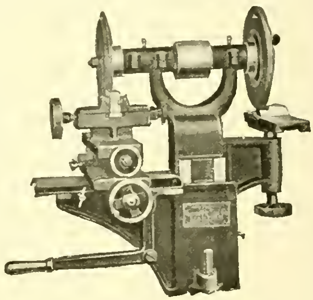
Price quoted after knowing requirements.

It can also be equipped with a Geometric Collapsing Tap or a Reversing Tap Holder for inside threads as well, according to the size of hole to be tapped. The range of tapping that is possible with this machine is from $\frac{1}{8}$ inch to 2 inches, and even to 3 inches where the pitch of thread is fine.

GEOMETRIC CHASER OR DIE GRINDER

Continued accuracy is naturally the chief requirement of all screw-cutting operations. With the Geometric Chaser or Die Grinder the difficulties of hand grinding are overcome and all chasers of a set may be ground uniformly to within a close limit of tolerance. It is adapted for grinding *any make* of thread chaser, whether of a stock or special type.

Speed of countershaft	690 RPM
Actual floor space required	25 x 25″
Net weight of machine	230 lbs.
Net weight of countershaft	35 lbs.
Gross weight	375 lbs.



Chasers in Place for Grinding on Throat and Face

GEOMETRIC ADJUSTABLE HOLLOW MILLING TOOL

These tools are specially designed for brass finishing and will be found most effective and economical for reducing duplicate parts to an exact diameter prior to threading. They can also be used for light cutting on cast iron, steel or similar material. They are made from solid bar steel and are extremely simple and durable.

SPECIFICATIONS AND PRICES

Size, Ins.	Diam. of Head, Ins.	Length of Head, Ins.	Diam. of Shank, Ins.	Length of Shank, Ins.	Length Over All, Ins.	Capacity with Complete Set of Cutters, Ins.	No. of Single Sets to a Complete Set	No. of Single Cutters to a Single Set	Price, incl'd'g Complete Set of Carbon Steel Cutters	Extra Carbon Steel Cutters, per Single Set	Extra High-Speed Cutters, per Single Set	Code Word
$\frac{7}{16}$	$1\frac{15}{16}$	$1\frac{1}{4}$	$\frac{7}{8}$	3	$4\frac{1}{4}$	$\frac{1}{8}$ to $\frac{7}{16}$	2	4	$12.00	$1.00	$1.50	Turn
$\frac{3}{4}$	$2\frac{3}{4}$	$1\frac{9}{16}$	$1\frac{1}{4}$	$4\frac{1}{4}$	$5\frac{13}{16}$	$\frac{1}{4}$ to $\frac{3}{4}$	3	5	16.00	1.25	1.88	Tire
$1\frac{1}{4}$	$3\frac{5}{8}$	$1\frac{15}{16}$	2	6	$7\frac{15}{16}$	$\frac{3}{4}$ to $1\frac{1}{4}$	2	5	20.00	1.50	2.25	Thine
2	$4\frac{3}{8}$	$1\frac{15}{16}$	$2\frac{3}{4}$	$6\frac{1}{2}$	$8\frac{7}{16}$	$1\frac{1}{4}$ to 2	3	5	30.00	1.50	2.25	Tole
$2\frac{1}{2}$	$4\frac{7}{8}$	$1\frac{15}{16}$	$3\frac{1}{4}$	$7\frac{1}{2}$	$9\frac{7}{16}$	$1\frac{1}{2}$ to $2\frac{1}{2}$	4	5	35.00	1.50	2.25	Tell
3	$5\frac{5}{8}$	$1\frac{15}{16}$	4	$8\frac{1}{2}$	$10\frac{7}{16}$	2 to 3	4	7	40.00	2.25	3.38	Talk
$3\frac{1}{2}$	$6\frac{1}{8}$	$1\frac{15}{16}$	$4\frac{1}{2}$	$8\frac{1}{2}$	$10\frac{7}{16}$	$2\frac{1}{2}$ to $3\frac{1}{2}$	4	7	45.00	2.25	3.38	Tick
4	$6\frac{5}{8}$	$1\frac{15}{16}$	5	$8\frac{1}{2}$	$10\frac{7}{16}$	3 to 4	4	7	50.00	2.25	3.38	Thank

IDEAL TOOL & MANUFACTURING CO.

BEAVER FALLS, PA.

MANUFACTURERS OF SCREW CUTTING DIES

THE IDEAL OPENING DIE

Opens by power of cutting strain: The cutting strain in all opening dies has a tendency to revolve the head holding chasers and not the cam. It is obvious therefore that by allowing the head of our die to revolve, we convert the cutting strain into an opening power instead of depending on springs.

Head revolves instead of cam: The superiority of this construction over dies which depend on the life and variation of a spring for their successful operation, will be apparent to every mechanic. Spring actuated devices are notably unreliable, and apt to be out of order when most needed.

Faulty alignment overcome: We have designed in our die an equalizing driving clutch which compensates for any imperfection in alignment of either the turret or the material being threaded.

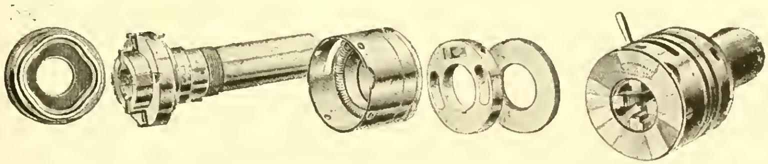
Chasers supported: The support for chasers in the Ideal Die puts an end to the tipping evil. They are supported by a hardened cam directly over and slightly preceding the point of strain. This chaser support together with the equalizing driving clutch, eliminates taper threads and bad work generally.

Four chasers instead of three: The advantage of four chasers over three is obvious. With four chasers you have the cutting points opposite, while with three chasers, as soon as one chaser becomes dull, it crowds the metal between the other two, thereby producing work that is not round.

Half as many parts: The Ideal Die has few parts and is easy to take apart and assemble.

Detachable Shank: The detachable shank makes it possible to use the same die in different sized machines.

Left and Right Hand Threads: The same die will cut either left or right hand threads; the former by simply changing index from right hand to left hand, and using left hand chasers.



Size	$\frac{1}{4}$ inch	$\frac{1}{2}$ inch	$\frac{3}{4}$ inch	1 inch	$1\frac{1}{4}$ inch
Diameter of head	$1\frac{11}{16}$ in.	$2\frac{1}{4}$ in.	$2\frac{15}{16}$ in.	$3\frac{9}{16}$ in.	$4\frac{11}{16}$ in.
Length of head	$1\frac{5}{8}$ in.	$1\frac{7}{8}$ in.	$2\frac{1}{2}$ in.	$2\frac{3}{4}$ in.	$3\frac{1}{2}$ in.
Diameter of shank	$\frac{5}{8}$ or $\frac{3}{4}$ in.	$\frac{7}{8}$ or $1\frac{1}{8}$ in.	$1\frac{1}{4}$ or $1\frac{1}{2}$ in.	$1\frac{1}{2}$ or $1\frac{3}{4}$ in.	$1\frac{3}{4}$ or $2\frac{3}{4}$ in.
Length of shank	2 in.	$2\frac{1}{2}$ in.	3 in.	4 in.	$4\frac{1}{4}$ in.
Length over all	$3\frac{5}{8}$ in.	$4\frac{3}{8}$ in.	$5\frac{1}{2}$ in.	$6\frac{3}{4}$ in.	$7\frac{3}{4}$ in.
Capacity	$\frac{3}{32}$ to $\frac{1}{4}$ in.	$\frac{1}{8}$ to $\frac{1}{2}$ in.	$\frac{1}{4}$ to $\frac{3}{4}$ in.	$\frac{3}{8}$ to 1 in.	$\frac{1}{2}$ to $1\frac{1}{4}$ in.
Chasers in set	4	4	4	4	4
With 1 set of chasers	$25.00	$30.00	$40.00	$50.00	$65.00
Extra shanks, each	4.00	5.00	6.00	7.00	8.00
Standard chasers per set	1.25	1.50	2.00	2.50	3.00
Special chasers per set	2.00	2.50	3.00	3.50	4.00
H. S. Steel Extra	1.00	1.00	1.00	1.00	1.00

One set of Standard pitch chasers, either U. S. V. or Whitworth, right or left hand furnished with die.

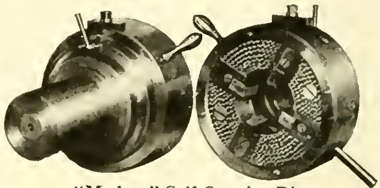
For sizes desired not listed in table above send specifications.

MODERN TOOL COMPANY

ERIE, PA., U. S. A.

SELF OPENING DIE HEADS, ADJUSTABLE SOLID DIES, TAP AND DIE HOLDERS, CHASER GRINDERS, FRICTION AND POSITIVE DRIVE MAGIC CHUCKS, TAPPING ATTACHMENTS, AND MODERN GRINDING MACHINES; MAKERS OF SPECIAL TOOLS.

"MODERN" SELF OPENING DIES

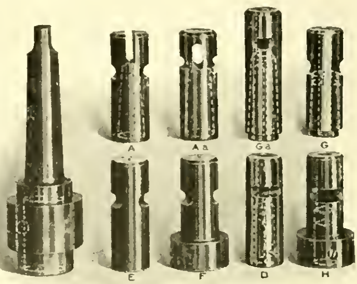


"Modern" Self Opening Die

The advantages of the "Modern" Die are many. The Die opens automatically when the thread is cut. No reversing of the machine. The return is 2½ to 1. No danger of injuring either the thread or Die. 50% to 80% in time and wear to belts and countershaft is saved. The "Modern" is the one Die having a steel cam to hold Chasers in place directly over point of duty, making it impossible for Chasers to bell at the mouth and preventing irregular or taper thread. When a large amount of stock is to be removed or precision required, a roughing and finishing attachment will be furnished.

"Modern" Chasers are cut all on a hob and are made either of carbon or high speed steel.

"MAGIC" CHUCK EQUIPMENT

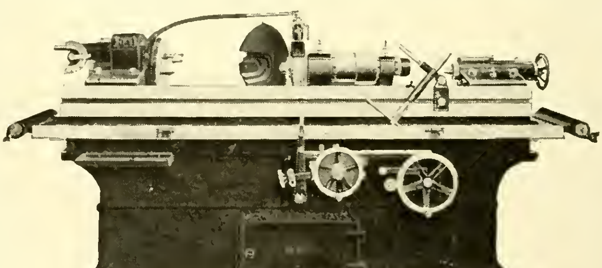


"Magic" Chuck and Collets

For the rapid changing of tools in drill press, lathe, screw machine, etc., without stopping the machine, practically converting a single spindle machine into a multiple spindle one, with as many tools as you may have operations. Try it and save labor cost.

"MODERN" GRINDING MACHINES

Much unnecessary weight is eliminated and perfect rigidity and freedom from vibration secured by the scientific distribution of material in "Modern" Grinding Machines. Generous bearings for all moving parts reduce the possibility of wearing and prevent absolutely all chatter. Centralization of working parts secures perfect transmission of power to the working point. Accessibility of the working parts for care and attention by the operator makes minimum loss of use, cost of up-keep and depreciation. Improved operative features insure large production and precision work.



"Modern" Grinding Machine

ALL "MODERN" TOOLS GUARANTEED TO BE SATISFACTORY TO THE USER

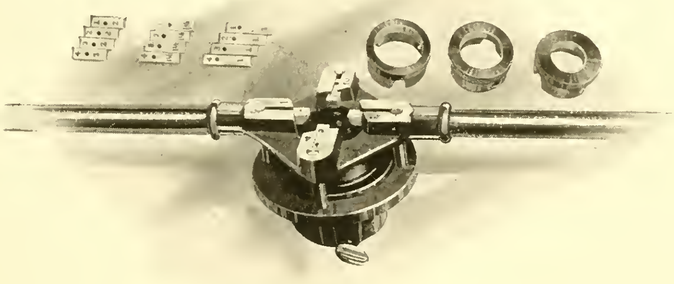
Complete information concerning products will be mailed interested parties upon request.

THE TOLEDO PIPE THREADING MACHINE CO.

TOLEDO, OHIO, U. S. A.

MANUFACTURERS OF PIPE THREADING DEVICES, VISES, PORTABLE VISE MOUNTS, AND KINDRED ARTICLES

"TOLEDO" PIPE THREADING DEVICES



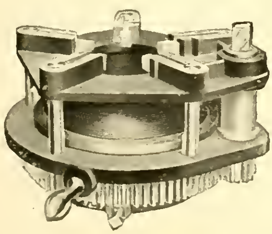
A line of hand-operated threading devices that are justly celebrated. Manufactured in twelve models to satisfy every need in pipe-threading from ⅛-inch to 12 inches inclusive. In the simplest conceivable form "TOLEDO" PIPE-THREADING DEVICES embody mechanical principles which have made possible the threading of pipe by hand with an ease unbelievable to those not familiar with "TOLEDO" tools.

One man can easily operate any "TOLEDO."

The best proof of their efficiency is that more than one hundred thousand (100,000) "TOLEDOS" have been made and sold.

	Capacity Pipe Size	List Price
No. 0 "Toledo" Adjustable Threading Device.......	⅛″ to ¾″	$16.00
No. 1 "Toledo" Adjustable Threading Device.......	1″ to 2″	24.00
No. 1A "Toledo" (Ratchet) Adj. Threading Device..	1″ to 2″	30.00
No. 10 "Toledo" Adjustable Threading Device......	1″ to 2″	28.00
No. 10A "Toledo" (Ratchet) Adj. Threading Device..	1″ to 2″	34.00
No. 1½R "Toledo" (Ratchet) Adj. Threading Device.	2½″ and 3″	50.00
No. 2 "Toledo" (Ratchet) Geared Adj. Thread. Device.	2½″ to 4″	100.00
No. 25 "Toledo" (Ratchet) Geared Adj. Thread. Device	2½″ to 6″	230.00
No. 3 "Toledo" (Ratchet) Geared Adj. Thread. Device.	4½″ to 8″	300.00
No. 4 "Toledo" (Ratchet) Geared Adj. Thread. Device.	9″ to 12″	500.00

Note.—Nos. 1 and 1A also made (reversed in all their parts) as left-hand threading devices at same price as the regular right-hand tools.

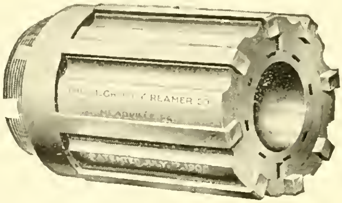


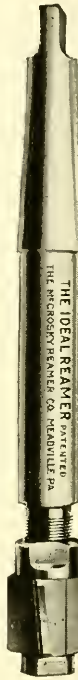
We also manufacture the	Capacity Pipe Size	List Price
"Vosper" Pipe Cutter.....	⅛″ to 2″	$16.00
"Toledo" Ratchet Geared Pipe Cutter............	2½″ to 6″	80.00
"Toledo" Pipe Vise No. 1..	⅛″ to 2½″	10.00
"Toledo" Pipe Vise No. 2..	⅛″ to 4½″	20.00
"Toledo" Vise Mounts No. 0	up to 1¼″	12.00
"Toledo" Vise Mounts No. 1	up to 2″	15.00
"Toledo" Vise Mounts No. 2	up to 4″	18.00

THE McCROSKY REAMER CO.

MEADVILLE, PA.

ADJUSTABLE REAMERS, EXPANDING MANDRELS, WIZARD QUICK-CHANGE CHUCKS AND COLLETS, WIZARD VARIABLE SPEED AND REVERSING ATTACHMENT for drill press, **SEARCHLIGHT UNIVERSAL LAMP BRACKETS** for shop and drafting room, **AND OTHER COST-CUTTING SPECIALTIES.**



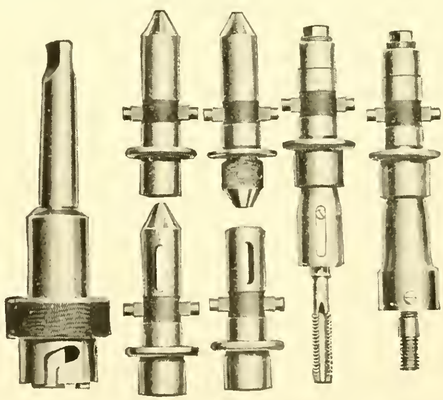


If you are in any way personally responsible for reaming results in your shop, you should familiarize yourself with this line of reamers. All styles and sizes from $\frac{3}{4}''$ to $10''$. High speed or carbon. Unequalled in design, unexcelled in workmanship and material, combining all the advantages of both solid and adjustable reamers without the disadvantages of either.

Hundreds of the largest and best shops have adopted these reamers as standard equipment. We solicit the privilege of figuring on your requirements.

WIZARD QUICK-CHANGE CHUCKS AND COLLETS

will revolutionize any drill press job where it is desired to use more than one tool in succession. Takes all sizes and kinds of tools, such as drills, taps, reamers, special tools, etc., in rapid succession without stopping the machine. On many jobs will show 50% saving. Embodies several important features not found in any similar device. Wizard friction drive collets are unequalled for tapping and stud setting. Wizard No-Needa-Tang collets reclaim broken tang drills and forever end all tang troubles.



Try a Wizard outfit on thirty days approval and watch it make dollars for you. We take the risk.

Our complete catalog of cost-cutting tools sent on request.

NORTON COMPANY

WORCESTER, MASS. U. S. A.

New York Store
151 Chambers St.

Chicago Store
11 N. Jefferson St.

Electric Furnace Plants
Niagara Falls, N. Y.—Chippawa, Can.

Manufacturing Plants
Worcester, Mass.—Wesseling, Germany

ALUNDUM AND CRYSTOLON GRINDING WHEELS, ALUNDUM AND CRYSTOLON GRAIN FOR POLISHING, ALUNDUM REFRACTORIES AND LABORATORY WARE, GLASS CUTTING WHEELS, INDIA OIL STONES AND CRYSTOLON SHARPENING STONES, RAZOR HONES, SCYTHE STONES, VALVE GRINDING COMPOUND, RUBBING BRICKS AND STONES, GRINDING WHEEL DRESSERS, GRINDING MACHINERY.

ALUNDUM (Al_2O_3) is made from Bauxite by fusion in an electric arc furnace. Its hardness, sharpness and toughness—"temper"—are under control. This, in combination with its characteristic conchoidal fracture, makes Alundum grinding wheels peculiarly effective upon materials of high tensile strength—notably steel and its alloys.

CRYSTOLON is Silicon Carbide (SiC) in crystalline formation. By the use of the purest materials and a scientifically correct process, an abrasive material of wonderful purity and remarkable cutting qualities is obtained. Its characteristic property of brittleness makes it highly efficient upon cast iron, brass, marble and other materials of low tensile strength.

REFRACTORIES—Until the invention of the process for making Alundum, Bauxite was considered infusible. This well-known property has made Alundum especially valuable as a refractory material. Alundum is made into Electric Furnace Cores, Tubes and Muffles; Crucibles, Combustion Boats, Filtering Crucibles and Cones, Extraction Thimbles and Refractory Cements.

Any of these booklets upon request: Alundum, Catalog of Grinding Wheels, Alundum-Crystolon Grinding Wheels, Alundum Grain for Polishing, Alundum and Crystolon in the Glass Industry, Norton Alundum Refractories, Helps—Don'ts For All Who Grind, Grinding Wheels for the Saw Mill, Norton Valve Grinding Compound.

SPECIAL RESEARCH SERVICE

We have well equipped research laboratories with a competent staff of research workers and demonstrators who are always ready to give you the benefit of their special knowledge and wide experience in the solving of your special problems.

Alundum — NORTON — Crystolon

FRANK MOSSBERG COMPANY

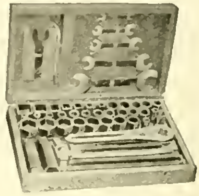
ATTLEBORO, MASS.

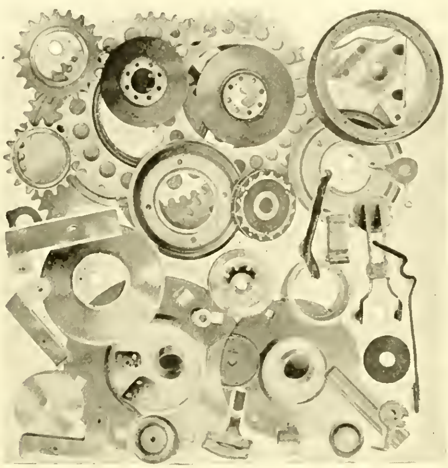
MANUFACTURERS OF SPECIAL MACHINERY AND TOOLS, PUNCHING DIES AND METAL STAMPINGS; AUTOMOBILE PARTS; REELS, BEAMS, SPOOLS, WRENCHES, BELLS.

Look For This Mark

Every article we make is **absolutely guaranteed.** We make 155 different kinds of wrenches for all kinds of work—but only one quality—**The Best.**

Mossberg socket wrench sets with No. 350 Mossberg ratchet handle and any combination of sockets.





METAL STAMPINGS

We are specialists in steel stamping, drawing and punching.

The art of working steel in this manner has been developed by us to a very high degree, and we are turning out, as a part of our every day product, work that until recently would have been utterly impossible.

We are prepared to furnish stampings large or small, either rough or as finished parts. Our product includes finished motor cycle and automobile parts, finished clock parts and finished parts for all classes of light machinery, besides a wide variety of rough stampings.

We particularly solicit inquiries for manufacturing finished parts for small machines. Our mechanical facilities are unexcelled and we guarantee all our work to be strictly high grade in every respect, while the scale on which we manufacture enables us to quote very favorable prices.

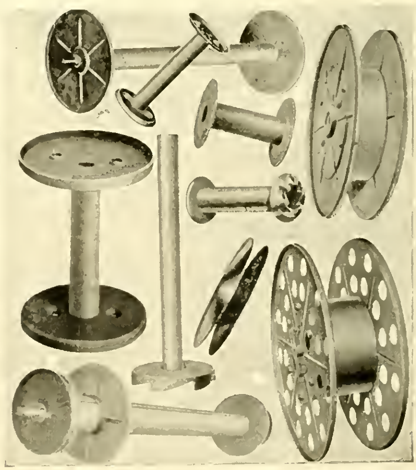
REELS—BEAMS—SPOOLS

We are pioneers in the manufacture of metal reels, beams, spools, etc. We were the first to use steel for this purpose. To-day it is generally recognized that Mossberg stamped steel reels, etc., not only are more satisfactory for general use but, owing to their low cost and greater durability, they are also more economical.

We solicit an opportunity to demonstrate this to any firm using any kind of reels, beams or bobbins.

We are prepared to furnish reels, etc., from the smallest commercial size up to the big 72″ cable reels—weighing 1500 pounds each.

Special catalog of reels and other parts for the textile trade, also complete reel catalog, which includes reels for wire and other industries, on request.



J. H. WILLIAMS & CO.

BROOKLYN, N. Y.

DROP-FORGINGS

THE ⟨W⟩ HANDBOOK OF SUPERIOR DROP FORGINGS

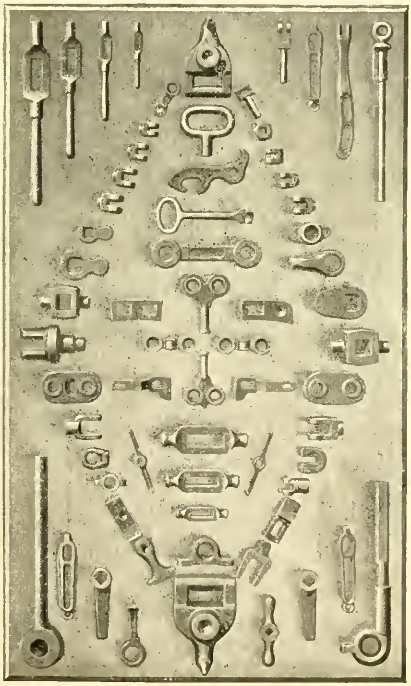
The pocket size book will not only show you the latest standard prices of our many drop-forged stock tools and accessories, but should convince you of our ability to take care of such "made to order" pieces as you may require in connection with your business affiliations.

It will prove a handy reference book to you for anything in Superior Drop-forgings!

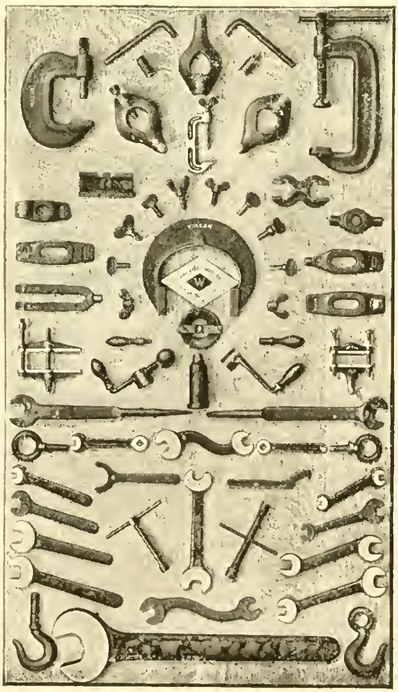
Among the new lines of Drop-forged tools you will notice that the "Vulcan" Safety Lathe Dogs are so constructed that all danger from sleeve contact has been eliminated.

The new "Agrippa" Clamps present unusual features at same price customarily paid for the cast steel product. The drop-forged "Agrippa" Clamps are lighter, stronger, have greater utility and will accomplish everything possible with the heaviest form of cast steel product.

Moreover, you will find interest in a number of other tools which possess points of merit and convenience unique to themselves; secure the book!



Special Forgings



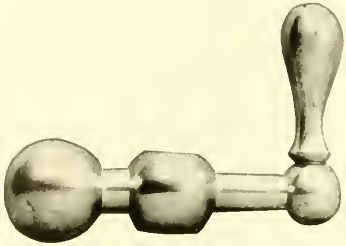
Stock Forgings

THE CINCINNATI BALL CRANK CO.

CINCINNATI, OHIO

STEEL PRODUCTS

STEEL BALL CRANK MACHINE HANDLES



No.	Length Over All	Center Ball	Large End Ball	Small End Ball	Price, Each
0	3	7/8	1	5/8	$0.51
1	3 1/2	1	1 1/8	3/4	56
1 1/2	4	1 1/8	1 3/8	7/8	68
2	4 1/2	1 1/4	1 3/8	7/8	68
3	5	1 5/16	1 1/2	1	72
4	5 1/2	1 5/16	1 1/2	1	78
5	6	1 3/8	1 5/8	1	81
6	6 1/2	1 3/8	1 3/4	1	90
7	7	1 7/16	1 3/4	1	94
8	7 1/2	1 1/2	1 3/4	1	98
9	8	1 1/2	1 3/4	1 1/16	1 01
10	8 1/2	1 9/16	1 3/4	1 1/8	1 10
11	9	1 5/8	1 3/4	1 3/16	1 14
12	11	1 3/4	1 7/8	1 1/4	1 40
13	13	1 15/16	2	1 1/4	1.50

Center ball can be drilled and faced any size desired.

Finished ready for use.

List prices subject to discount.

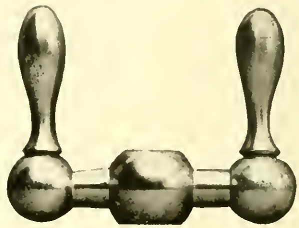
COMPOUND REST HANDLES

No.	Length Over All	Center Ball	End Balls	Price, Each	
1	2 1/2	1 1/16	3/4	$0.24	No handle in ends
2	2 1/2	1 1/16	3/4	52	Handle in one end
3	2 1/2	1 1/16	3/4	64	Handle in both ends
4	3	1 1/16	3/4	24	No handle in ends
5	3	1 1/16	3/4	52	Handle in one end
6	3	1 1/16	3/4	66	Handle in both ends
7	3 1/2	1 1/16	3/4	26	No handle in ends
8	3 1/2	1 1/16	3/4	54	Handle in one end
9	3 1/2	1 1/16	3/4	68	Handle in both ends
10	4	1 3/16	7/8	30	No handle in ends
11	4	1 3/16	7/8	60	Handle in one end
12	4	1 3/16	7/8	74	Handle in both ends

Center ball can be drilled and faced any size desired.

Finished ready for use.

List prices subject to discount.



MACHINE HANDLES

No.	Length of Shank	Length Over All	Diameter of Shank	Price, Each
000	1/2	1 13/16	1/4	$0.08
00	1/2	2	1/4	10
0	1/2	2 1/4	5/16	12
1	5/8	2 3/4	3/8	14
2	3/4	3 1/8	7/16	18
3	3/4	3 1/2	7/16	21
4	3/4	4	7/16	24
5	7/8	4 3/8	7/16	27
6	1	4 5/8	1/2	29
7	1	5 1/8	1/2	31
8	1 1/4	5 3/4	5/8	33

Finished ready for use.

List prices subject to discount.

TWO BALL LEVERS

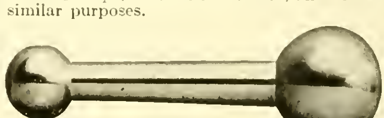
Adapted for Tail Stock, Tighteners, Drill Press Clamps, Back Gear Levers, and for all similar purposes.

No.	Length Over All	Large End Ball	Small End Ball	Price, Each
2	4 1/2	1 3/8	7/8	$0.60
4	5 1/2	1 1/2	1	64
6	6 1/2	1 3/4	1	76
8	7 1/2	1 3/4	1	82
10	8 1/2	1 3/4	1 1/8	88
11	9	1 3/4	1 3/16	96

Large ball can be drilled and faced any size desired.

Finished ready for use.

List prices subject to discount.



Perfect in Construction and Finish

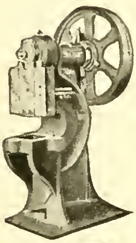
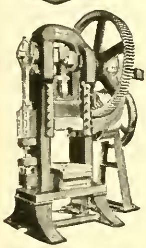
Manufactured as a specialty and sold below the manufacturing cost of cast iron or forged handles. Discount given *on application.*

Estimates given on large screw machine work, handles and screws of every description.

E. W. BLISS CO.

BROOKLYN, N. Y.

BUILDERS OF SHEET METAL WORKING MACHINERY

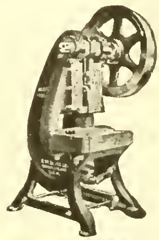
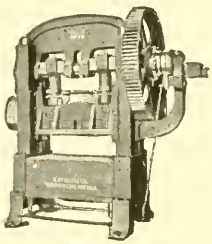
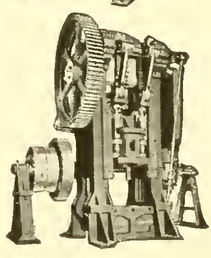

The most complete line of machines for sheet metal working in the world.

Presses for every ordinary kind of work and special machines for unusual requirements. Drop Forging machinery, Hinge and Butt machinery, Fork and Spoon machinery, Expanded Metal Lath machinery, Shovel machinery, Horse Shoe machinery, Minting machinery, Automobile Parts machinery, Spinning Lathes, Gang Slitters, Circle Shears, Perforating, Punching, Slitting, Shearing, Beading, Flanging, Crimping and Seaming machines.

Complete equipments for the economical manufacture of Petroleum and Alcohol Cans, Fruit and Vegetable Cans, (Sanitary and Packers'), Meat Cans, Paint and Varnish Cans, Lard Pails and Butter Tins, and all kinds of Tin Cannisters, Boxes and Packages.

Machinery for manufacturing Soft Metal Tubes, Tinware, Enamelware, Aluminum, and Silverware, Metal Shingles, Metal Ceilings, Sheet Metal Furniture, Kitchen Utensils, Kitchen Boilers, Oil Stoves, Lamps, etc., etc.

We are also equipped for die work of every description.

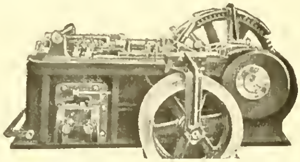
Catalogues describing any of our lines will be sent on request

No. 1. "Bliss" Inclinable Power Presses.
No. 2. "Stiles" Power Punching Presses.
No. 3. "Bliss" Straight-Side Power Presses.
No. 4. "Bliss" Drop Hammers and Trimming Presses.
No. 5. "Bliss" Toggle Drawing Presses and Spinning Lathes.
No. 6. "Bliss" Foot and Screw Presses.
No. 8. "Bliss" Double Crank Presses.
No. 9. "Bliss" Machinery for Manufacturing Tin Cans (Spanish).
No. 10. "Bliss' Machinery for Manufacturing Pieced Tinware.
No. 11. "Bliss" Minting Machinery.
No. 12. "Bliss" Machinery for Manufacturing Electrical Parts.
No. 13. "Bliss" Drop Forging Machinery.
No. 14. "Bliss" High Speed Automatic Can Making Machinery.
No. 15. "Bliss" Railway Motor Gears and Pinions.
No. 16. "Bliss" Machinery for Manufacturing Automobile Parts.

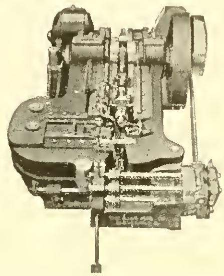
THE AJAX MANUFACTURING CO.

DETAILED TABLE OF FACTS CONCERNING AJAX MACHINES

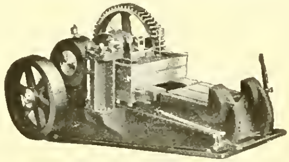
Machines		Sizes	No. Strokes Per Minute	Floor Space Without Back Stop	Diam. Blt. W.	Face Blt. W.
Bolt Heading, Upsetting, and Forging Machines		7″	26	20′ 4″ x14′ 6″	75½″	13″
		6″	30	19′ 0″ x13′ 9½″	75½″	13″
		5″	35	15′ 0″ x12′ 0″	58″	11″
		4″	40	13′ 4″ x 7′ 9″	56″	11″
		3½″	50	11′ 4″ x 7′ 4½″	42″	11″
		3″	55	11′ 0″ x 6′ 6″	40″	11″
		2½″	60	9′ 8″ x 6′ 4″	40″	11″
		2″	70	9′ 5″ x 6′ 0″	40″	9″
		1½″	75	8′ 4″ x 5′ 2″	33″	6½″
		1¼″	80	7′ 8″ x 4′ 6″	51″	7½″
		1″	90	7′ 4″ x 4′ 5″	48″	6″
		¾	100	7′ 0″ x 4′ 0″	48″	6″
Universal Upsetting and Forging Machines		6″	30	14′ 2″ x19′ 3¼″	75½″	13″
		5″	35	13′ 8″ x12′ 9″	58″	11″
		4″	40	13′ 6″ x10′10″	56″	11″
		3½″	50	11′ 7″ x 8′ 9″	40″	11″
		2½″	60	9′11″ x 8′ 4″	40″	11″
		1½″	75	8′11″ x 7′ 5″	40″	7″
Continuous Motion Heading Machines	Hand Feed	1¾″	45	12′ 6″ x 7′ 0″	60″	9″
		1½″	50	10′ 5″ x 6′ 4½″	60″	8½″
		1¼″	65	8′ 9″ x 6′ 0″	53″	8½″
		1″	70	8′ 0″ x 5′ 1″	50″	7″
		¾″	85	7′ 0″ x 4′ 4″	48″	6″
		½″	85	6′ 8″ x 4′ 0″	48″	6″
	Automatic	1¾″	60	12′ 5″ x 6′ 4½″	60″	8½″
		1½″	85	10′ 9″ x 6′ 0″	53″	8½″
		1¼″	90	10′ 0″ x 5′ 1″	50″	7″
		1″	100	9′ 0″ x 4′ 4″	48″	6″
		¾″	105	8′ 8″ x 4′ 0″	48″	6″
Ajax Special Axle Upsetting Machines		4″	40	13′ 4″ x 7′ 9″	56″	11″
		3½″	50	11′ 4″ x 6′ 7″	42″	11″
		3″	55	11′ 0″ x 6′ 6″	40″	11″
		2½″	60	9′ 8″ x 6′ 0″	40″	11″
		1½″	75	8′ 4″ x 5′ 2″	33″	6½″
Bulldozers or Bending Machines	Standard Slow Speed	No. 12	7	22′11″ x10′ 1″	36″	8½″
		No. 9	8	19′10½″x 8′ 5″	32″	6½″
		No. 8	8	18′ 6¾″x 8′ 0″	32″	6½″
		No. 7	9	15′10″ x 7′ 0″	26″	6″
		No. 6	10	13′ 8″ x 5′ 8″	26″	6″
		No. 5	11	13′ 4″ x 5′ 1″	26″	6″
		No. 4	12	12′ 2″ x 4′10″	26″	6″
		No. 3	17	9′11″ x 4′ 2″	18″	4″
	Stop Motion High Speed	No. 7	30	16′ 1½″x 7′ 3″	32″	7″
		No. 6	35	15′ 0″ x 6′ 4″	30″	7″
		No. 5	40	13′ 2½″x 5′ 9″	40″	8½″
		No. 4	45	10′ 6″ x 3′10″	34″	6½″
		No. 3	50	10′ 0″ x 3′ 6″	32″	5½″
		No. 2	60	8′ 0″ x 3′ 0″	26″	4¾″
		No. 1	60	4′11½″x 2′ 2″	20″	3½″
Hot Pressed Nut Machines		2″	45	12′ 0″ x 6′ 0″	48″	10″ Geared
		1½″	50	11′ 6″ x 3′10″	40″	7″
		1¼″	55	11′ 2″ x 3′ 8″	45″	6½″
		1″	60	10′11″ x 3′ 6″	33″	6½″
		¾″	65	9′10″ x 3′ 3″	53″	6½″
Ajax Rolls	Taper-Forging	No. 4	28	8′11″ x 7′ 8″	54″	8½″
		No. 3	30	7′11″ x 6′10″	54″	8″
		No. 2	38	6′10″ x 5′10″	44½″	6½″
		No. 1	50	6′ 4″ x 5′10″	44½″	6½″
		No. 0	50	4′10″ x 3′ 8″	33″	5″
	Brake Shoe Key Taper-Forging	Special	50	4′10″ x 3′ 8″	33″	5″
	Reclaiming	Trio	75	17′ 6″ x 7′ 6″	40″	8½″
Ajax Hot Saw and Burring Machines		14″	2,000	2′ 7″ x 2′ 11″	6″	4″
		20″	1,400	3′ 3″ x 3′ 1½″	8″	5″
		30″	725	3′ 8½″x 4′ 2½″	9½″	5½″



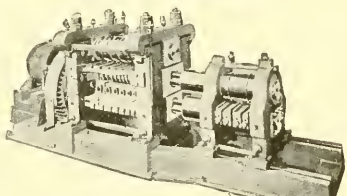
Bolt Heading and Forging Machine



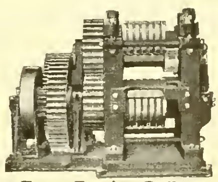
Automatic Feed Heading Machine



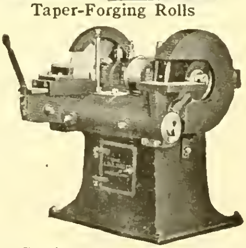
High-Speed Bulldozer



Reclaiming Rolls



Taper-Forging Rolls



Hot Sawing and Burring Machine

CLEVELAND CITY FORGE & IRON CO.

CLEVELAND, OHIO

11 Broadway, New York — Ford Bldg., Detroit, Mich.

IRON AND STEEL FORGINGS

TURNBUCKLES

The "Cleveland" Turnbuckle has been adopted as STANDARD by the United States Government Engineers and is specified by them on Government work.

It is guaranteed STRONGER than any medium steel rod which it fits.

The metal is so distributed in the various sections that a maximum of strength is obtained.

The OPEN CONSTRUCTION is very desirable. The bolt ends are always in sight, allowing inspectors to readily see that they have a good hold on the thread, and also that the ends do not butt together. This form of turnbuckle can be adjusted with a bar or wrench.

CLEVIS NUTS

The standard Clevis Nuts which we manufacture are acknowledged to be the best and neatest in design of any in the market.

The PIN connection is on a dead center with the head.

The PIN HOLES are true in line, being drilled by special machinery.

LIGHT FORGINGS

Automobile Forgings a specialty and Drop Forgings of every description—Journal Box Wedges; Center Plates.

Bulldozer and Upsetting Work, including all manner of Car Forgings and Structural Rods.

HEAVY FORGINGS

Marine:—Rudder Frames, Rudder Stocks, Stern Frames, etc.

Shafts:—Round, Square, Hexagon, Crank, Thrust, Eccentric, etc.

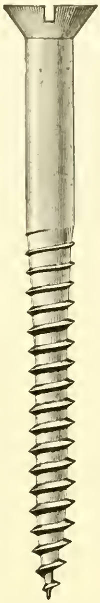
Rolls:—Bending, Sugar Mill.

General Steam Hammer work.

PRESSED STEEL PRODUCTS

We have a full equipment of Heavy Hydraulic Presses for both hot and cold pressed work:—Steel Car Doors, Carlines, Automobile and Truck Frames.

Flat Head **Oval Head**



Drive Screw **Round Head**

WOOD SCREWS

Flat and Round Head Wood Screws are regularly made in Iron in the following sizes, and in Brass in sizes of approximately the same variety; other kinds of Wood Screws are made in the sizes commonly used.

Length.....	¼	⅜	½	⅝	¾	⅞	1	1¼	1½	1¾
Min. Dia...	0	0	1	1	2	2	3	3	3	5
Max. Dia...	4	9	12	14	16	16	20	24	24	24
Length.....	2	2¼	2½	2¾	3	3½	4	4½	5	6
Min. Dia...	5	5	5	6	6	8	8	12	12	12
Max. Dia...	24	24	24	24	26	26	30	30	30	30

Intermediate diameters advance as follows: No. 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 20 22 24 26 28 30

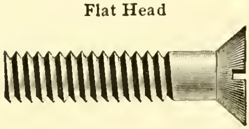
MACHINE SCREWS

Flat, Round, and Fillister Head Machine Screws are regularly made in Iron in the following sizes, and in Brass in sizes of approximately the same variety:

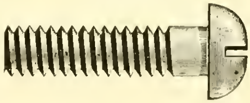
Length.....	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½
Min. Dia...	2	2	2	2	2	2	2	2	2	3	4	4	4	4	4
Max. Dia....	10	14	16	24	24	24	24	26	34	34	34	34	34	34	34
Length.....	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4	4¼	4½	5	6	
Min. Dia....	6	6	8	8	8	8	10	10	12	12	12	14	14	16	
Max. Dia....	34	34	34	34	30	30	30	30	30	30	30	30	30	30	

Intermediate diameters advance as follows: No. 2 3 4 5 6 7 8 9 10 12 14 16 18 20 22 24 26 28 30 34

Flat Head



Round Head



Fillister Head

Diameter No.	2	3	4.5	6	7	8	9.10	12	14
Threads per in.	48.56.64	48.56	32.36.40	30.32.36	30.32	30.32.36	24.30.32	20.24	18.20.24
	16.18	20.22	24	26 28.30	34				
	16.18.20	16.18	14.16.18	14.16	13				

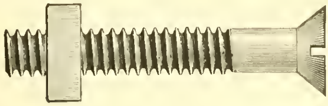
Regular Side Knob Screws  are ⅜ inch No. 9, 24 thread.

See also next page.

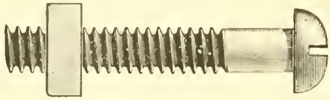
AMERICAN SCREW COMPANY

STOVE BOLTS

Flat Head



Round Head



Flat and Round Head Iron Stove Bolts are regularly made in the following sizes:

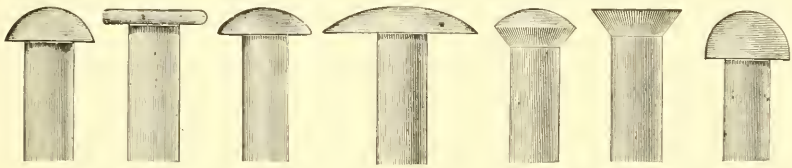
Diameter	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$
Min. Length	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	1
Max. Length	2	2	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	3

The length advances by eighths of an inch from $\frac{3}{8}$ to $\frac{1}{2}$, then by quarters to $6\frac{1}{2}$.

STOVE RODS

Stove Rods are the same as Stove Bolts in every respect excepting length. They are regularly made in Iron of $\frac{3}{16}$ and $\frac{1}{4}$ diameter in length from 7 to 40,″ advancing by halves of an inch.

RIVETS



Cold-headed Rivets are made in great variety of styles and sizes up to $\frac{7}{16}$ in diameter and 6 in length.

MEASUREMENTS

The length includes the head of Flat Head Screws, Stove Bolts, and Stove Rods; excludes the head of Round and Fillister Head Machine Screws and Round Head Stove Bolts and Stove Rods; includes the countersink of Oval Head Screws and about half the head of Round Head Wood Screws, but the practice with regard to Round Head Wood Screws is not uniform with all makers.

The length of Rivets is exclusive of the head for all styles with a right angle under the head, and inclusive of the countersink for countersunk heads.

The diameter of Screws is measured by the American Screw Gauge, the equivalent in inches being:

0	.0578	5	.1236	10	.1894	15	.2552	22	.3474
1	.0710	6	.1368	11	.2026	16	.2684	24	.3737
2	.0842	7	.1500	12	.2158	17	.2816	26	.4000
3	.0973	8	.1631	13	.2289	18	.2947	28	.4263
4	.1105	9	.1763	14	.2421	20	.3210	30	.4526
								34	.5053

The diameter of Rivets is measured by the Old Standard Birmingham Wire Gauge, the equivalent in inches being:

000	.425	2	.284	6	.203	10	.134	14	.083
00	.380	3	.259	7	.180	11	.120	15	.072
0	.340	4	.238	8	.165	12	.109	16	.065
1	.300	5	.220	9	.148	13	.095	17	.058
								18	.049

See also preceding page.

THE BRAEBURN STEEL COMPANY

BRAEBURN, PENNSYLVANIA

"THE TOOL STEEL MILL"

GRADES 1, 2, 3

These grades are carbon crucible steels corresponding in properties respectively to the best makes of standard, extra, and special tool steel. They are made in all tempers and each grade is uniform both as to chemical analysis and method of manufacture as well as to working properties. A reference to our catalogue will give more information regarding these steels.

GRADE 4

This is a special steel for Turning, Planing and Slotting hard materials, Expensive Cutters, Drills, Forming Tools, Taps, Punches, Dies, etc., and is particularly recommended for all kinds of tools where special endurance is sought and where great strength and toughness are required. This steel is made in all tempers.

GRADE 5

This is a very hard steel made in one temper only for Turning, Planing, Slotting and working Chilled Iron or any other hard material and especially for those purposes where the tool has to carry a fine edge and has to put a very fine finish on the work. It is not intended for tools which have to withstand shocks like the blows of a hammer or sledge.

Treatment. This steel should be given more time in heating for forging and hardening than other tempering steels. For forging, heat slowly and uniformly to a bright red, then forge the tool, using light blows as the heat dies out; do not hammer at a black heat. For hardening, reheat to a dark red and quench in warm water.

Use a wet grindstone in grinding tools made from this steel.

GRADE 6

This is an oil hardening steel, made only in one temper, for Milling Cutters, Taps, Reamers, Gauges, Hard Steel Bushes, Ball Bearings and other purposes where it is particularly desired there shall be neither contraction nor expansion after hardening.

Treatment. For forging, heat slowly and uniformly to a bright red, harden at a dull red, about 1350 degrees Fahrenheit and draw the temper only sufficiently to relieve the strain. Hardened in this manner it is very tough and takes an excellent cutting edge and practically obviates all contraction and expansion.

GRADE 7

This is a deep hardening steel and is especially recommended for Twist Drills and is made in all tempers.

SELF HARDENING

This is a special alloy steel which cannot be cut or punched cold but can be shaped or ground on a stone or emery wheel. It is suitable for moderately high speeds where great strength is not necessary.

HIGH SPEED STEELS

Made in two grades known as "High Speed" and "High Speed Special."

The HIGH SPEED STEEL for Punches, Boring Tools, Straight Drills, Twist Drills, Milling Cutters, Gear Cutters, etc., is capable of doing all the work of ordinary machine shop equipment with heavy cuts and coarse feed at either high or low speed.

The HIGH SPEED SPECIAL STEEL is for purposes similar to those for which the High Speed Steel is made but is adapted more particularly to cases where the service is unusually severe. We recommend the use of this steel only where unusual service is demanded or where it is desirable to use a tool for a considerable length of time without re-grinding. This steel, owing to its superior quality and toughness, of course holds its edge longer and stands greater strains than does the High Speed Steel, but its use is hardly necessary or economical except under unusually severe conditions.

B. T. GRADE

A common tool steel suitable for Springs, Shafts, Forgings, Hammers, Picks, Forks, Rakes, Hoes, Corn Stalk Cutters, Cutlery, Lawn Mowers, Harvesting Machinery, Wedges, Swedges, Die Blocks, Cant-Hooks, Files, etc., or wherever well selected and carefully worked steel is used.

THE COLONIAL STEEL COMPANY

PITTSBURGH, PENNSYLVANIA

HIGH GRADE STEEL

COLONIAL HIGH SPEED STEEL

Adapted for the heaviest cuts or the highest speeds on all classes of material. Colonial High Speed Steel is made in one grade only and is capable of doing any class of work for which high speed steel is suited.

COLONIAL BEST TOOL STEEL, WATER HARDENING

An alloy steel adapted for fine finishing cuts, such as forming tools, cutters, hobs, threading dies, etc.; for brass and copper lathe tools, and other purposes where machines are not equipped to use high speed tool steel.

COLONIAL NO. 7 TOOL STEEL, WATER HARDENING

A vanadium tool steel of great strength and toughness; made from pure wrought iron, and suitable for high-class tools of all kinds, especially those subject to strain or stress of any kind through repeated action or repeated shock.

COLONIAL SPECIAL TOOL STEEL, WATER HARDENING

A straight carbon tool steel, made from pure melting iron. Suitable for shop tools of all kinds.

RED STAR TOOL STEEL

Standard grade for ordinary purposes.

RED STAR DRILL STEEL

For rock drilling purposes.

NICKEL STEEL—CHROME VANADIUM STEEL

Bars and Sheets made in small furnaces and carefully melted to insure homogeneous steel. Furnished free from pipes, seams and all defects.

30 PER CENT NICKEL STEEL BARS and SHEETS

Anti-corrosive. Used for valve stems and parts of internal combustion engines. or other purposes where material is desired that will not rust or corrode.

SHEET STEEL

For knives and tools of all kinds, springs, agricultural implements, etc.

SOFT CENTER PLOW STEEL

Made in slabs or sheared to pattern, carefully manufactured, and special attention given to the toughness of center, and rigidly inspected.

FIVE PLY JAIL BARS AND SAFE PLATES

Send for Catalog

WHEELOCK, LOVEJOY & COMPANY

NEW YORK — BOSTON

HIGH GRADE STEEL

Agents

THOMAS FIRTH & SONS, LTD.,
SHEFFIELD, ENG.
Cutlery and Saw Steel

FIRTH STERLING STEEL COMPANY,
PITTSBURG, PA.
Makers Highest Grade Tool Steel

WEST PENN STEEL CO.,
BRACKENRIDGE, PA.
Cold Rolled and Electrical Sheet Steel

Agents

GLOBE WIRE CO., LTD.,
SHARPSBURG, PA.
Polished Drill Rods, Needle Wire
Drawn Steel in Special Shapes

WEST LEECHBURG STEEL COMPANY,
PITTSBURG, PA.
Hot and Cold Rolled Strip Steel

BRIGHTMAN MFG. CO.,
COLUMBUS, OHIO
Turned, Ground and Polished
Shafting and Screw Stock

HY-TEN STEEL

This steel is of high tensile strength and elastic limit, especially intended for machine tool parts where good wearing qualities combined with great strength and toughness are essential.

A complete stock is carried in warehouses for prompt shipment.

FIRTH-STERLING "BLUE CHIP" HIGH SPEED STEEL

Suitable for Lathe and Planer Tools, Milling Cutters, Drills, Reamers, Taps, Cutting and Blanking Dies, etc.

"Blue Chip" High Speed Steel is carried in stock in the following sizes and shapes:

SQUARES, $\frac{1}{4}$ in. to $\frac{5}{8}$ in. Hard Steel ready for use.
$\frac{3}{16}$ in. to 3 in. Annealed.

ROUNDS, $\frac{3}{16}$ in. to 10 in. Annealed.

FLATS, $\frac{3}{8}$ in. x $\frac{1}{8}$ in. to $5\frac{1}{2}$ in. x $\frac{7}{8}$ in. Annealed.
$\frac{1}{2}$ in. x $\frac{1}{4}$ in. to $3\frac{1}{8}$ in. x 2 in. Annealed.

Special sizes can be secured promptly from the mill.

FIRTH-STERLING TOOL STEELS

Other high grade Firth-Sterling Steels carried in stock by Wheelock, Lovejoy and Company are in part as follows:

Firth's Best Tool Steel (Water Hardening), a strictly high grade carbon tool steel for general service.

Firth-Sterling Special Steel. For Punches, Dies, Chisels, Blacksmith Tools, Shear Blades, Rivet Snaps and all Shop Work.

Sterling Tool Steel. This steel is made to compete with the lower grades on the market, and will compare favorably with them. Carried in stock in Rounds, Flats, Squares and Octagons.

ALLOY STEELS

To meet the increased demand for steels that are more effective than carbon steels, and of a different character from High Speed Steel, we have developed the following which we now recommend for various purposes:

Firth-Sterling "Extra Special" Steel
Firth-Sterling "Double Special" Steel
"Hold Fast" Magnet Steel
"C Y W Choice" Steel
"A W Special" Steel
Firth-Sterling Finis Steel

"TOOL STEEL FOR EVERY PURPOSE"

THE BAYONNE CASTING COMPANY

GENERAL OFFICES AND WORKS, BAYONNE, N. J.

MONEL METAL; BRASS, BRONZE, ALLOYS

MONEL METAL

Monel Metal contains approximately 67% nickel, 27% copper and 6% of other metals, principally iron and manganese; and with its high tensile strength and its non-corrosive properties greatly excels the best Manganese, Tobin or Phosphor Bronze.

Cast Monel Metal has a tensile strength of 70,000 lbs. per square inch, while the rolled metal is much stronger, having a tensile strength of 80,000 to 100,000 lbs. per square inch.

In appearance, Monel Metal cannot be distinguished from pure nickel and takes the same finish. Its great strength, together with its extreme incorrodibility, admirably adapt it for use in marine work and engineering construction, for parts that come in contact with salt water and for valves and fittings that are subjected to superheated steam.

Monel Metal can be furnished in any of the following forms: CASTINGS, RODS AND BARS, WIRE, FORGINGS, BOLTS AND NUTS.

MONEL METAL CASTINGS

CASTINGS: The greatest tonnage of Monel Metal Castings made up to the present time has gone into propellers for the U. S. Navy and private yachts. The Navy has also purchased castings for pump linings, steam turbine nozzles and valve fittings for superheated steam. Many castings have been made for use in dairy machinery, refrigerating plants, and pickling apparatus in steel mills. Various other castings that have been made are thermometer wells, gear blanks, large washers and nuts, deck fittings for yachts, pump parts, radiator castings, etc.

RODS: Hot rolled Monel Metal rods up to 6″ diameter have been furnished principally for pump rods. Small sizes of rounds and squares are extensively used for bolt and nut stock. Rolled rods are now used for steam turbine parts, stock for drop forgings, electrical apparatus, motor boat shafting, pickle pins and valve stems.

WIRE: Monel Metal wire can be furnished in all gauges from B & S No. ½″ up to No. 40. It is used for wire cloth, motor cycle spokes, rope for wire hoists and cableways, nails, screws, rivets, etc., and innumerable other applications where high tensile strength, combined with non-corrosive features are essential.

FORGINGS: Monel Metal forgings show tensile tests, equivalent to steel. The importance thereof can be readily appreciated for parts of gas, oil or internal combustion engines of all types; automobile and motor boat fittings; steam turbine fittings and innumerable applications requiring a metal that will stand up under the most severe conditions.

The Bayonne Casting Company can make castings of Monel Metal from customers' patterns, of any size or description up to 25,000 lbs. in weight in one piece. The plant has been equipped to produce such castings as promptly and at as low a cost as is compatible with first-class workmanship. They will be pleased to furnish hot rolled rods at the lowest prices. Monel Metal can be obtained in the form of ribbon, round and flat wire, although this is not carried in stock because of the great variations in sizes required. Prices of forgings, bolts and nuts of the various types and sizes will be promptly quoted on request.

GENERAL ELECTRIC COMPANY

General Office: SCHENECTADY, N. Y.

Branch Offices:

Atlanta, Ga.	Cincinnati, Ohio	Jacksonville, Fla.	Nashville, Tenn.	Salt Lake City, Utah
Baltimore, Md.	Cleveland, Ohio	Joplin, Mo.	New Haven, Conn.	San Francisco, Cal.
Birmingham, Ala.	Columbus, Ohio	Kansas City, Mo.	New Orleans, La.	St. Louis, Mo
Boise, Idaho	Davenport, Iowa	Keokuk, Iowa	New York, N. Y.	Schenectady, N. Y.
Boston, Mass.	Dayton, Ohio	Knoxville, Tenn.	Omaha, Neb.	Seattle, Wash.
Buffalo, N. Y.	Denver, Colo.	Los Angeles, Cal.	Philadelphia, Pa.	Spokane, Wash.
Butte, Mont.	Detroit, Mich.	Louisville, Ky.	Pittsburg, Pa.	Springfield, Mass.
Charleston, W. Va.	(Office of Agent)	Mattoon, Ill.	Portland, Ore.	Syracuse, N. Y.
Charlotte, N. C.	Elmira, N. Y.	Memphis, Tenn.	Providence, R. I.	Toledo, Ohio
Chattanooga, Tenn.	Erie, Pa.	Milwaukee, Wis.	Richmond, Va.	Washington, D. C.
Chicago, Ill.	Indianapolis, Ind.	Minneapolis, Minn.	Rochester, N. Y.	Youngstown, Ohio

For Texas and Oklahoma business refer to Southwest General Electric Co. (formerly Hobson Electric Co.)—Dallas, El Paso, Houston and Oklahoma City.
For Canadian business refer to Canadian General Electric Company, Lt'd, Toronto, Ont.

COMPLETE ELECTRICAL POWER PLANT EQUIPMENTS AND SUPPLIES

The General Electric Company is the largest electrical manufacturer in the world. The monogram trade mark is known all over the world. It is the Guarantee of Excellence on Goods Electrical.

GENERATING APPARATUS

The Curtis turbine is built in all sizes from the smallest exciter set to the 20,000 Kw. size—the largest in the world. They are suitable for condensing or non-condensing service, and are also furnished in low pressure or exhaust steam and mixed pressure types. The latter can be used with high or low pressure steam or both. Steam extraction turbines are furnished where exhaust steam is needed for heating or manufacturing purposes. Engine driven generators are regularly furnished in capacities ranging from 25 to 1,000 Kw. direct current and from 50 to 5,000 Kw. alternating current. Water wheel driven generators have been built in all desired sizes and voltages up to 10,000 horsepower at 11,000 volts. The General Electric Company has had more experience than any other company in building high voltage generators. These machines do not deteriorate in their windings and are very conservative in temperature ratings.

Gasolene Electric Generators are specially designed for 35, 65 and 125 volts direct current circuits in sizes ranging from 1 to 25 Kw. Alternating current sets are available in the 10 and 25 Kw. sizes.

SYNCHRONOUS CONVERTERS—MOTOR GENERATORS

Synchronous converters and motor-generator sets provide an economical method for changing electric power of any standard frequency and voltage from alternating to direct current or vice versa.

SWITCHBOARDS

The development of an extensive line of standardized switchboard units is a great advantage to the purchaser of switchboards. For all ordinary requirements the necessary panels can be selected from the G-E catalogs of Standard Unit Panels, and combined into a switchboard that will satisfy every requirement of the installation. The advantages are convenience in ordering, prompt shipment and low price, the latter two resulting from the elimination of engineering and drafting on the individual order.

For high voltage plants and other cases where unusual requirements must be met, special switchboards are designed to meet any conditions of control.

Switchboard specialists are located at many of the principal offices of the company and will furnish data which will enable the engineer to specify a complete switchboard especially adapted to his particular requirements and with all parts built, assembled and tested as a unit by one company.

INSTRUMENTS—METERS

Switchboard and testing instruments and all kinds of electric meters cover fully the requirements for measurement of power.

REGULATORS

Automatic regulators are furnished for keeping the voltages constant on alternating or direct current power and lighting circuits.

4094

GENERAL ELECTRIC COMPANY

TRANSFORMERS

The Type H transformer for lighting circuits is used by the majority of Central Stations throughout the country. High voltage power transformers are designed especially for reliability under the severest of operating conditions.

LIGHTNING-ARRESTERS

For protecting lines and apparatus the General Electric Company manufactures several different types of lighting-arresters. For D. C. Circuits of different voltages, two types of magnetic blowout arresters are available. Where a very high degree of protection is desired, direct current aluminum arresters are furnished.

For alternating current circuits two different types of multigap arresters give a high degree of perfection for all the lower voltages. The Multigap arrester with graded shunt resistance gives selective paths to ground and has no series resistance so that it freely discharges heavy strokes. It is used for protecting generators and other station apparatus.

The compression chamber multigap arrester is a low priced arrester suitable for protecting pole transformers or other apparatus where the expense of installing the graded shunt resistance arrester is not justified. For all voltages above 6600 the aluminum arrester is recommended as giving the best protection obtainable.

WIRE AND CABLE

The General Electric Company manufactures wires and cables insulated with paper, varnished cambric, rubber or composite (graded) insulation. To meet different conditions of service these cables are furnished with protective coverings of cotton, asbestos, lead, band steel or wire armor.

LAMPS, INCANDESCENT AND ARC

Standard lighting units ranging from a 10 watt Edison Mazda lamp to the flame arc lamp for lighting large areas are carried in stock. Lighting specialists and illuminating engineers of the General Electric Company will assist in laying out any lighting system.

WIRING DEVICES

G-E Reliable wiring devices include panel boards, fuses, switches, terminals, insulators, etc. All these devices are N. E. C. standard.

MOTORS AND CONTROLLERS

For all power installations, complete lines of standard motors including slow speed and back geared types are furnished for either hand or distant control. Automatic starting panels are fast becoming standard for heavy duty motors, or for motors located at a distance. The motor may be started by the push button method or operated automatically by float switches (for constant water levels) or pressure governors (for pressure control). The General Electric Company has a motor for every power application—a controller for every motor, and specialists who can assist in the combined application to obtain best results in the plant.

FLOW METERS

The General Electric Company has developed a practical device for measuring the flow of steam in pipes. The G-E Steam flow meter can be installed in any sized pipe at a small expense, and will give reliable readings of the flow. They are specially useful in the boiler plant and turbine room for measuring the output of the individual boiler and the input of the turbines. G-E Flow Meters are also furnished for measuring the flow of water, air and natural gas.

BULLETINS—FURTHER INFORMATION

Only a few of the products of the General Electric Company are described above. Bulletins, giving information, illustrations and full data on complete electrical apparatus for the power house will be mailed on application from our nearest office.

4094

THE ROBBINS & MEYERS CO.

FACTORY AND GENERAL OFFICES, SPRINGFIELD, OHIO

District offices and agencies in all important cities

MANUFACTURERS OF ELECTRIC GENERATORS, MOTORS AND FANS

"STANDARD" GENERATORS—Direct Current

These generators have been designed with special reference to their use for small lighting plants. They are self-oiling, and when not used in connection with storage battery work are self-regulating.

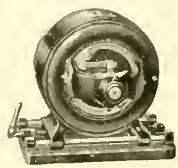
They are guaranteed to be of the very best material and workmanship, free from mechanical and electrical defects, and guaranteed to carry their rated load continuously without attaining a temperature greater than 40 degrees Centigrade in excess of that of the surrounding air. They are regularly wound, either shunt or compound, for standard voltage of 115 volts direct current, and specially wound, usually shunt, at 30 to 60 volts for charging storage batteries.

For Generators driven by gas or gasoline engines we furnish a fly wheel pulley on the Generator; these flywheels have permanently attached pulleys and the heavy rims of the flywheels partly overhang the bearings.

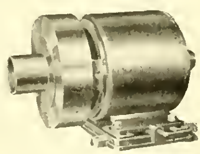
CAST IRON FRAMES

K. W. Rating	No. of 25 W. 20 C. P. Tungsten Lamps	Speed R. P. M.	Net Weight	Ship'ng Weight
½	20	1850	95	145
¾	30	1750	160	215
1	40	1650	190	250
1½	60	1550	220	280
2	80	1400	320	410
3	120	1300	400	510
4	160	1200	565	680
5	200	1100	740	855
7½	300	1000	900	1025
9	360	1100	1148	1288
10	400	975	1215	1355

See Bulletin No. 43.



C. I. Frame Generator



Steel Frame Generator

STEEL FRAMES

Frame No.	Kilowatt Rating	No. of 25 W. 20 C. P. Tungsten Lamps	Speed	Net Weight	Shipping Weight
51	¼	10	2000	40	75
43	¼	10	860	60	90
43	½	20	1720	60	90
42	½	20	1000	85	110
43	¾	30	2600	60	90
42	¾	30	1500	85	110
60	¾	30	900	135	200
42	1	40	2000	85	110
60	1	40	1200	135	200
60	1½	60	1700	135	200
60	2	80	2200	135	200

See Bulletin No. 93.

"STANDARD" MOTORS—Direct Current

The Standard Ventilated Type Motors are guaranteed to carry their full rated load continuously without attaining a temperature greater than 40 degrees Centigrade in excess of that of the surrounding air. They will also carry 25% overload for one hour without dangerous heating and a momentary overload of 100% without destructive sparking.

Frame No.	H. P.	Speed: 110 and 220 Volts	Speed: 500 Volts	Net Weight with Sliding Base	Net W'ght without Sliding Base	Shipping W'ght with Base and Starting Box
¼	¼ ⅓	1650 2200	1650 2200	80	65	125
½	¼ ½	800 1600	1700	95	83	145
¾	½ ¾	1000 1575	1100 1750	160	135	215
1	½ ¾ 1	750 1100 1500	825 1200 1600	190	165	245
1½	¾ 1 1½ 2	700 900 1400 1800	800 1000 1500 1850	220	200	285
2	1 1½ 2 3	550 875 1100 1600	600 950 1200 1650	320	280	100

Frame No.	H. P.	Speed: 110 and 220 Volts	Speed: 500 Volts	Net Weight with Sliding Base	Net Weight without Sliding Base	Ship'ng W'ght with Base and Starting Box
3	2 3 4	800 1150 1600	1000 1350 1750	400	360	500
4	3 4 5	800 1000 1400	900 1200 1500	600	543	700
5	5 7½	900 1300	975 1400	740	665	850
7½	7½ 10	900 1200	1000 1300	900	800	1060
10	7½ 10	750 1000	750 1000	1150	1050	1350
12½	12½ 15	850 1080	1000 1200	1200	1135	1410

Fully described in Bulletin No. 51.

THE ROBBINS & MEYERS CO.

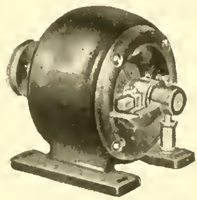
The "Standard" Motors in Small Frames

These small Motors are all thoroughly well built of the best materials and by expert workmen. They are of high average efficiency and are fully as durable as the largest size machines. They may be absolutely relied upon for years of satisfactory service.

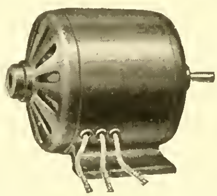
CAST IRON FRAMES

Frame No.	H. P.	Speed 115 and 230 Volts	Net Weight	Sh'p'g W'ght
1/10	1/30 1/20 1/16 1/10	1000 1500 2000 3000	4 1/2	10
40	1/16 1/12 1/8	1000 1500 2000	16	20
1/8-B	1/16 1/10 1/8	1000 1200 1600	25	35
1/7	1/8 1/7 1/6	1700 2000 2300	18	22
1/7-P	1/16 1/10 1/8 1/6	1000 1500 1800 2400	20	25
1/6-C	1/8 1/6	1200 1600	33	42
1/6-D	1/6 1/4	1500 2000	35	44

See Bulletin No. 95.



Frame No. 1/8 B.



Frames 42, 43, 54 and 60 with Ventilated End Covers

STEEL FRAMES

Frame No.	H. P.	Speed 115 and 230 Volts	Net Weight without Sliding Base	Shipping Weight
49	1/12 1/8	1150 1750	17	40
41	1/8 1/6	1150 1750	20	41
54	1/8 1/6 1/4	900 1150 1750	35	75
43	1/4 1/3 1/2	900 1150 1750	55	90
42	1/2 3/4 1	800 1150 1750	80	110
60	3/4 1 1 1/2	875 1150 1750	130	200

See Bulletin No. 91.

Frame No. 1/10 is the smallest and only frame which may be run on either alternating or direct current, at present supplied. Frame No. 40 is an adaptation of the "Standard" Fan Motor to small power purposes. Frame No. 1/8-B is designed primarily to deliver 1/8 H.P. at 1600 r.p.m. for constant service. Frame No. 1/7 is practically the same size as No. 40, but can meet harder service conditions. Frame No. 1/6-C has the same lines as Frame No. 1/8-B, but delivers the power at a lower rate of speed. Frame No. 1/6-D is intended for heavy intermittent service and is provided with dust-proof covers when required.

Our Lathe and Buffing Motors are described in Special Bulletin No. 79.

The adoption of Steel Motor Frames has resulted in a line of frames unusually compact and light for the output. Binding posts are ordinarily dispensed with, flexible terminals brought out through brushed holes in the body, being used.

Type "P" Alternating Current Induction Motors

The Type P Motors embody many distinct features, being simple in construction, ruggedly built, with heads arranged for floor, wall and ceiling suspension mountings.

TYPE P—SINGLE PHASE
60 Cycles, 110 or 220 Volts

Frame No.	H. P.	Speed	Net Weight	Shipping Weight
14	1/30	1750	15	25
15	1/20	1750	18	28
16	1/10	1750	21	32
17	1/8	1750	27	38
18	1/6	1750	35	50
19	1/4	1750	45	60
14	1/40	1150	15	25
15	1/30	1150	18	28
16	1/20	1150	21	32
17	1/10 or 1/8	1150	27	38
18	1/6	1150	35	50
19	1/4	1150	45	60

Fully described in Bulletin No. 99.

TYPE QP—2 PHASE, TYPE TP—3 PHASE

Frame No	Speed	H. P.	Voltage	Net Weight	Shipping Weight
16	1750 1150	1/8 1/10	110–220 110–220	21 21	32 32
17	1750 1150	1/6 1/8	110–220 110–220	27 27	38 38
18	1750 1150	1/4 1/6	110–220 110–220	35 35	50 50
19	1750 1150	1/2 1/4	110–220 110–220	45 45	60 60
20	1750 1150	1 1/2	110–220 110–220	60 60	85 85

This Company also manufactures the "Standard" line of Ceiling, Desk, Bracket, Oscillating Desk, and Exhaust Fans for direct and alternating current, Dynamotors, Motor-Generators, etc.

INGERSOLL-RAND COMPANY

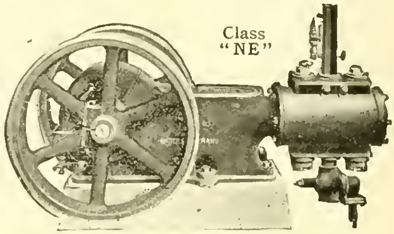
11 Broadway, NEW YORK, U. S. A.

Offices in all Principal Cities of the World

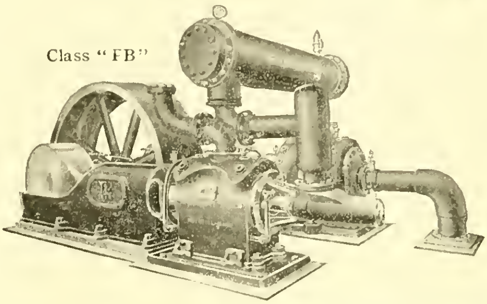
BUILDERS OF AIR AND GAS COMPRESSORS, PNEUMATIC HAMMERS, PNEUMATIC DRILLS, AIR MOTOR HOISTS, AIR MOTORS, PNEUMATIC SAND RAMMERS, AIR LIFT PUMPS, AIR POWER MACHINERY OF ALL KINDS.

POWER DRIVEN COMPRESSORS

Ingersoll-Rand types in this series provide for drive by gear, silent chain, belt, rope, or direct shaft connection to electric motor or water wheel. Straight line and duplex units are offered—single stage, two stage, or multi-stage.



Class "NE"



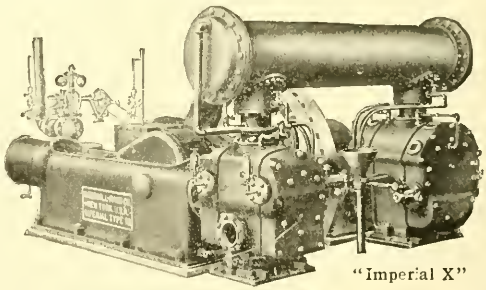
Class "FB"

In each type details of design and construction have been carefully worked out to secure the best efficiency consistent with the size and style of unit, and the utmost wearing quality. Capacities in various types, 4 to 5700 cu. ft. per minute; all pressures up to 3000 lbs.

Bulletins No. 3107, 3008, 3310 and 3312.

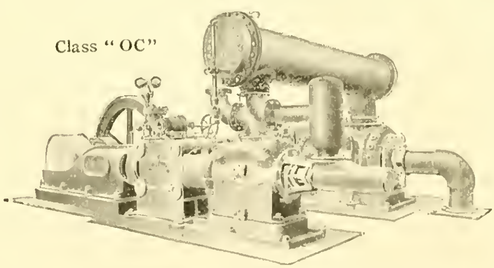
STEAM DRIVEN COMPRESSORS

In this series are machines with plain slide valve, balanced Meyer adjustable cut-off valve, and drop-release Corliss valve. In straight line types simple steam cylinders are used. Duplex types have duplex simple or cross-compound steam cylinders, condensing or non-condensing.



"Imperial X"

Bulletins No. 3106, 3209, 3311 and 3123.



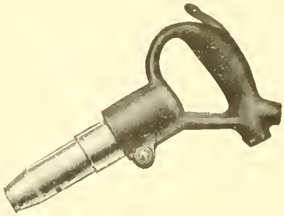
Class "OC"

Every refinement consistent with type and size has been employed to make the largest volume of compressed air per hundred lbs. of steam used — permanent economy being the ideal sought. Capacities in various types, 96 to 8000 cu. ft. per minute; all pressures up to 3000 lbs.

Descriptive Bulletins on Request

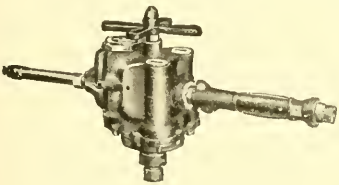
INGERSOLL-RAND COMPANY

"LITTLE DAVID" AND "IMPERIAL" PNEUMATIC HAMMERS



Ingersoll-Rand Hammers for chipping, riveting, caulking, sealing, etc., are made in a complete range of sizes and in two distinct types, meeting every condition. The Company maintains its regular standard in this line, as representative of the quality of the complete Ingersoll-Rand line.

Bulletins No. 8011 and 8103.

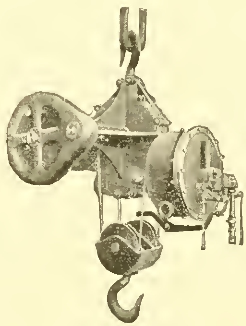


"LITTLE DAVID" PNEUMATIC DRILL

This is a new machine, built and sold on the following basis:—It has only two-thirds as many parts as any other drill—does more work per unit of power than any other—requires less attention and costs less for repairs than any other. All standard sizes and types.

Bulletin No. 8107.

"IMPERIAL" AIR MOTOR HOISTS



The hoisting problem—handling work and materials in shop, foundry, warehouse, factory—finds its most economical solution in this silent-running, self-oiling, wholly-enclosed, self-braking hoist. The five sizes have capacities of ½, 1, 2, 3½ and 5 tons, working under ordinary pressures.

Bulletin No. 8005.

"IMPERIAL" AIR MOTORS
(Not Illustrated)

This is a high-grade 3-cylinder wholly-enclosed motor splendidly adapted for running grinders, small tools, small cranes, or other light intermittent service. Two sizes give 2 and 3¼ H. P.

Bulletin No. 8006.

"CROWN" SAND RAMMERS

Experience all over the country has demonstrated that improved castings, larger output, and lower castings cost result from the adoption of "Crown" Pneumatic Rammers in the foundry. And they are built to withstand the hard conditions of foundry service. Both floor and bench types can be had. This machine has also proved useful in ramming concrete in construction work.

Bulletin No. 8008.

Descriptive Bulletins on Request

NATIONAL BRAKE & ELECTRIC CO.

WORKS AT MILWAUKEE, WIS.

DISTRICT SALES OFFICES:

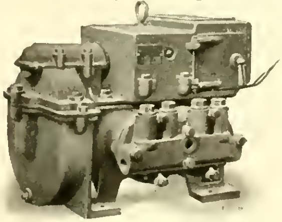
165 Broadway New York	827 Railway Exchange Chicago, Ill.	318 Security Bldg. St. Louis, Mo.	9th and Penn Ave. Pittsburgh, Pa.

MANUFACTURERS OF NATIONAL AIR COMPRESSORS, BOTH STATIONARY AND PORTABLE, MOTOR, GAS, AND BELT DRIVEN

The National Brake & Electric Co. are the pioneers in the designing and building of motor-driven air compressor units. Its products are designed by specialists of extended experience in the art and are manufactured in shops especially equipped for the production of motor driven air compressors.

NATIONAL STATIONARY COMPRESSORS

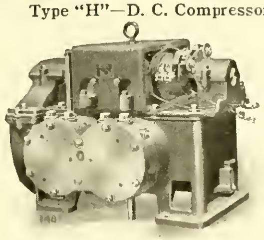
Primarily these compressors were designed for use in connection with air brake equipments in electric cars, a service requiring an unusual degree of efficiency, reliability, compactness, ease of access and quiet operation. They have been carefully developed to their present state of perfection and embrace advanced features of construction.



Type "H"—D. C. Compressor

TYPE "H"—D. C. MOTOR DRIVEN

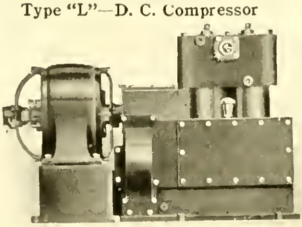
These compressors with capacities ranging from 11 to 50 cubic feet of free air per minute are built for pressures not exceeding 100 pounds, unless otherwise specified. They are equipped with D. C. motors of the enclosed type and are built for intermittent service, with limited periods of work and rest.



Type "L"—D. C. Compressor

TYPE "L"—D. C. MOTOR DRIVEN

When conditions necessitate a continuous supply of compressed air in small quantities, National Type "L" Compressors will be found singularly adapted to such requirements. This type of compressor is built in capacities ranging from 11 to 40 cubic feet of free air per minute and designed for pressures not exceeding 100 pounds unless otherwise specified.



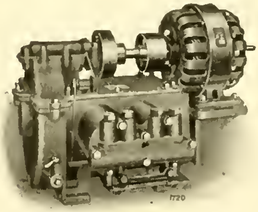
Type "E"—D. C. Compressor

TYPE "E"—D. C. MOTOR DRIVEN

These compressors are built for continuous service in capacities of 50 to 100 cubic feet of free air per minute and for pressures not exceeding 100 pounds, unless otherwise specified.

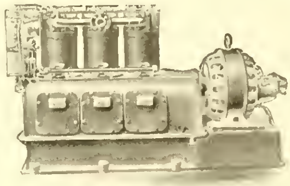
TYPES "H," "L" AND "E"
A. C. Motor Driven—1, 2 and 3 phase

Standard polyphase induction motors require that the compressor be unloaded at the time of starting and all types H, L & E induction motor driven compressors (2 and 3 phase) are equipped with a manual unloader, unless otherwise specified. When complete automatic control is desired, polyphase alternating current motor driven compressors can be furnished with National Automatic Governor for closing and opening the motor circuits when the air pressure has reached a predetermined minimum or maximum, together with a National Centrifugal type Unloader, which automatically unloads the compressor at the time of shutting down and keeps it in an unloaded state until the motor has again been started and attained nearly its normal full speed.



Type "H"—A. C. Compressor

NATIONAL BRAKE & ELECTRIC CO.



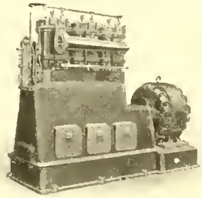
Type "3VS"—A. C. Compressor

TYPE "3VS"—A. C. AND D. C. MOTOR DRIVEN

The National Type "3VS" Air Compressor has been designed to meet the constantly increasing demand for a self-contained electrically driven air compressor unit.

The air compressors of this type have completely water-jacketed cylinders and cylinder heads; are designed for continuous service, and are built in standard capacities of 50, 100, 150, 225 and 300 cubic feet of free air per minute.

Type "3VS" motor driven compressors are equipped with complete automatic controlling devices, which permit the starting of the direct current compressors with not to exceed one half full load current, and the alternating current compressors with not to exceed full load current. They are also equipped with automatic unloader and automatically controlled water valves. National combined automatic controlling devices for motor driven compressors are absolutely reliable and efficient.



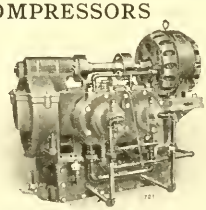
Type "3VD"—A. C. Compressor

TYPE "3 VD"—A. C. AND D. C. MOTOR DRIVEN

This compressor is designed for continuous service and is built in one size only, having a piston displacement of 550 cu. ft. per minute, and is equipped with the same design of combined automatic controlling devices as the "3VS", except being arranged for higher duty.

NATIONAL STATIONARY COMPOUND AIR COMPRESSORS

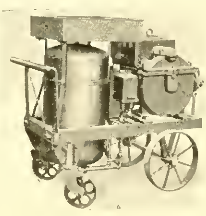
TYPE "Q-L" AND "Q-E"—A. C. AND D. C. MOTOR DRIVEN



Type "QL"—A. C. Compressor

National Type "Q" Compressors, with capacities ranging from 7 to 70 cubic feet of free air per minute, are intended for service where conditions necessitate the constant delivery of air at high pressures, within the maximum limits, however, of either 200 or 350 pounds. In the latter instance, the compressor, in comparison with that rated at 200 pounds pressure, will have reduced displacement capacity to offset increased pressure.

NATIONAL PORTABLE AIR COMPRESSORS



Type "H" Portable Compressor

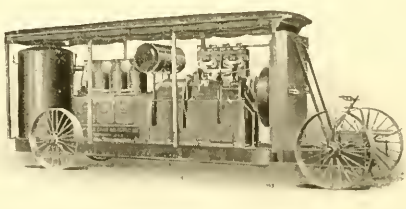
National Portable Air Compressor Outfits are ideally adapted for use in mercantile establishments, mines, quarries, manufacturing plants, and in construction work, where the available floor space is limited, or the nature of the work requires that a supply of compressed air be delivered in different places and under constantly changing conditions.

These portable outfits can be equipped with the same type of motor compressor and controlled in the same manner as any of the National Stationary Compressors previously described.

NATIONAL GAS DRIVEN AIR COMPRESSORS

STATIONARY AND PORTABLE

With the increased adoption of gas motors there has been a constantly increasing demand for "National Air Compressors" driven by gas motors. The same superior features of design that characterize National Type "E" and "3VS" motor driven compressors are embodied in National Type "E" and "3VS" Gas Driven Air Compressors.



Type "3VS" Gas Driven Portable Compressor

NATIONAL-STANDARD COMPANY

NILES, MICHIGAN

MANUFACTURERS OF AUTOMOBILE JACKS, COPPER CABLES, RAILROAD TRACK TOOLS, CATTLE GUARDS AND POSITIVE PRESSURE BLOWERS.

THE DURECO POSITIVE PRESSURE BLOWER

The Dureco Blower is the result of twenty-five years' practical experience in the manufacture of positive pressure blowers. It contains new and original improvements, covered by patents and patents applied for, which make it the most perfect machine of its kind ever offered.

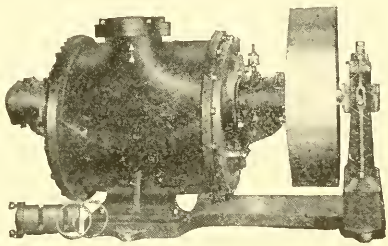
The Dureco Blower is of the impeller type, but is so constructed that there is no friction between the impellers and outer casing, all parts being accurately fitted, so there is a very slight clearance at all times. In efficiency the blower has few equals and no superior. There are no gears, thus the machine operates practically without noise, and being a slow speed blower less power is required to run it than high speed blowers.

In design and construction the Dureco Blower is most simple. It consists of one casing, two heads, one drum with *steel shafts*, three or four vanes, depending upon the size of the blower, and sliding shoes or rollers in each head for supporting the blades of the impellers. The blowers are equipped with bronze ring oiler bearings and in all sizes above No. 1/4 the bearings are adjustable.

These machines will operate successfully under pressure up to 5 lbs. or under dry vacuums of 12 inches. The bearings are so constructed as to form their own packing gland, thus there is no possibility of oil being sucked into the blower when operating under a vacuum, or being blown out when operating under pressure.

Points of Superiority

Requires a minimum amount of power.
Operates successfully at low speed.
Greatest efficiency.
Parts interchangeable.
Adjustable bronze bearings.
Steel Shafts.
Ring oilers.
No gears.
No springs.
Mechanically perfect.
Utmost durability.
Practically noiseless.
Fully guaranteed in every respect.



DURECO No. 1
(Patent Applied For)

SPECIFICATIONS

Size Blower	Dia. of Intake and Outlet Inches	Inside Measurement	Speeds	Cu. ft. free air delivered per minute	Cu. ft. free air delivered per revolution	Size of Pulley	Weight	List Price
000	1	7½ x 3	200 to 400	*18 to 36	.09	8 x 3	75	$40.00
00	1½	7½ x 6¾	300 to 400	39 to 52	.13	8 x 3	105	60.00
0	2	7½ x 9	200 to 400	56 to 112	.28	10 x 3	125	75 00
X	2½	10⅛ x 9	230 to 325	137 to 175	.55	12 x 4	215	110.00
⅛	3	10⅛ x 12	250 to 325	165 to 210	.66	12 x 4	230	140 00
¼	4	12 x 15	175 to 275	210 to 325	1.2	14 x 4	420	200 00
½	6	20 x 14	175 to 225	525 to 675	3	24 x 6	900	300 00
1	8	20 x 20	175 to 225	780 to 990	4 5	24 x 6	1400	400.00
2	10	24 x 25	175 to 200	1300 to 1500	7 5	30 x 8	1900	600 00
3	12	24 x 40	175 to 200	2200 to 2500	12.5	30 x 10	2500	800 00

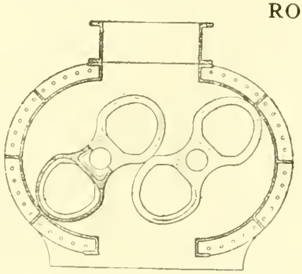
(*) Capacities are result of tests and can be relied upon.
We will be glad to quote prices and delivery on larger blowers.

P. H. & F. M. ROOTS COMPANY

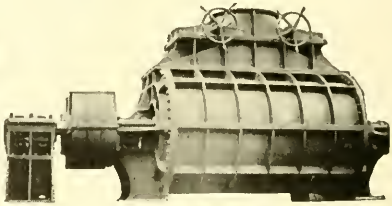
CONNERSVILLE, INDIANA

ROTARY BLOWERS, GAS EXHAUSTERS, ROTARY PUMPS, FLEXIBLE ROPE COUPLINGS

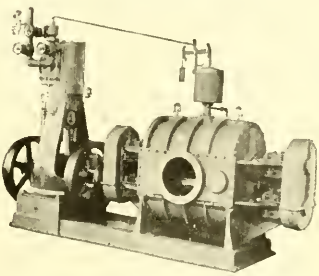
ROOTS' BLOWERS



Sectional View Showing Interior Construction



Double Outboard Bearing, Single Geared Smelting Blower with Double Acting Quick Opening Blast Gate



Engine Driven Gas Exhauster

FACILITIES

SIZE.—Our facilities are such that we can build Blowers up to sixty-inch gear machines, having a displacement of over seven hundred cubic feet per minute.

ACCURACY.—By the use of machines specially made for our work, we insure accuracy, which results in high efficiency, not once, but in all machines.

CAPACITY.—Is the largest of any Posiive Blower Company in the world.

SPECIAL MACHINES

We build special machines for handling gases. They can be bronze or lead lined, with or without stuffing boxes. The general construction is the same as Smelting or High Pressure Blowers.

GAS EXHAUSTERS

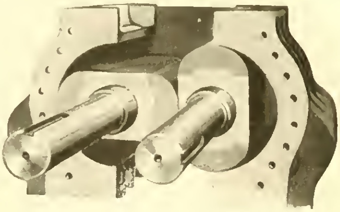
The Roots' Exhauster as built today, is the nearest approach to a perfect Rotary machine. It is strong throughout, without being cumbersome, work manlike in appearance, without sacrificing strength and durability to finish, easy to adjust, and has all adjustments in places easy of access, without removing one part to get at another.

TABLE OF SIZES, POWERS, AND CAPACITIES OF ROOTS' GAS EXHAUSTERS

No. of Exhauster	Suction and Discharge Diameters	Horse Power at Stated Speed and One Pound Pressure	Speed of Exhauster	Displacement in Cubic Feet per Revolution	Capacity per Hour in Cubic Feet No Allowance for Shrinkage
2	4	.75	200	.91	10,920
3	6	1.5	200	1.31	15,720
4	8	2.5	180	2.95	31,860
5	10	3.75	170	4.8	48,960
6	12	5.	160	8.3	79,680
7	16	7.50	150	13.1	117,900
8	16	11.	140	19.6	164,640
8½	20	15.5	130	28.2	219,960
9	20	19.	120	38.5	277,200
9½	20	24.	110	51.2	337,920
10	24	29.	100	61.75	370,500
10½	30	36.	95	81.	461,700
11	30	50.	90	111.2	600,480
11½	36	69.	90	147.9	798,660
12	36	80.	85	192.	979,200
12½	42	102.	85	244.	1,244,400
14	42	115.	80	304.9	1,463.520

P. H. & F. M. ROOTS COMPANY

ROOTS ROTARY PUMPS



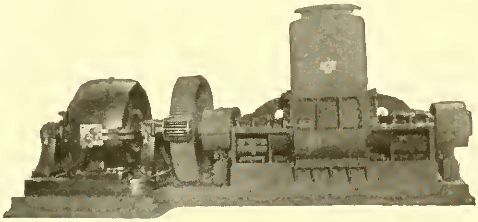
Interior Construction of Rotary Pump

The range of operation of these Pumps is from ten feet to two hundred feet head and for handling any liquid substance, not containing grit, with economy ranging from 75 per cent to 85 per cent of the power applied to the Pump shaft.

The source of power may be turbine, steam or motor, and any of these classes of power may be direct connected, geared or belt driven, thus giving a wide choice of arrangement and allowing the Pump to be used under almost any conditions.

Irrigation reservoir, condenser, cooling towers, circulating work for hot or cold water or brine, are a few among the many purposes to which the Pumps are successfully applied. The sizes range from the 50,000 gallons a minute irrigation pump, running 70 r.p.m., tc the small 1–10 gallon displacement per revolution Pump, running 600 r.p.m.

For handling oil, tar or ammonia, these pumps are well suited. Special lining and impellers may be used where the liquids to be pumped would attack cast iron.



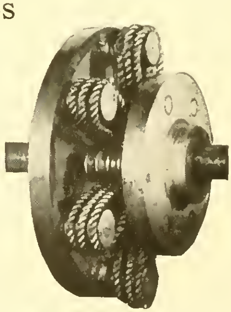
Direct Connected Motor and Pump

Briefly, the operation of the Pumps is as follows: The revolution of the shafts and impellers traps the water between the lobes and the case, delivers it to the discharge side, where the rolling together of the impellers on the center lines of the shaft prevents the return of the water.

The care and workmanship with which the impellers are fitted to each other and to the case assure a small slip of water both at the rolling and case contacts. The suction air chambers cast on the lower half of the half circles save unsightly pipe connections, at the same time stiffening the Pump as a whole.

The flow of water is steady and uniform, and unless air enters the suction pipe, free from pulsation.

FLEXIBLE ROPE COUPLINGS



This coupling was designed to meet a condition in rotary pump work, and proved so satisfactory for this work that it is now used on a large percentage of our direct connected Blowers, Exhausters and Pumps. The points of advantage that place it ahead of other designs for the same purpose are these:

FIRST—It corrects for misalignment in any direction, whether due to settling of foundations, wear of engine bearings, or original setting, thus saving uneven wear and heating.

SECOND—It takes care of end thrust caused by heating, wear of bearings or oscillations of the driving mechanism.

THIRD—It eases up sudden fluctuations of load by the swing of the loop.

FOURTH—It permits rotation in either direction, with equal results and symmetrical positions.

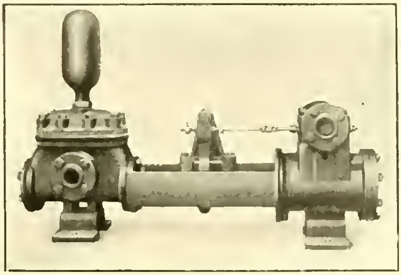
FIFTH—The ropes can be removed as quickly as the bolts in a solid coupling can be taken out.

SIXTH—With ropes off, either the driving or driven machine can be rotated without interference.

SEVENTH—The life of the ropes is long and can be renewed at small expense.

THE BLAKE & KNOWLES STEAM PUMP WORKS

MAIN OFFICE: 115 BROADWAY, NEW YORK
FACTORY: EAST CAMBRIDGE, MASS.

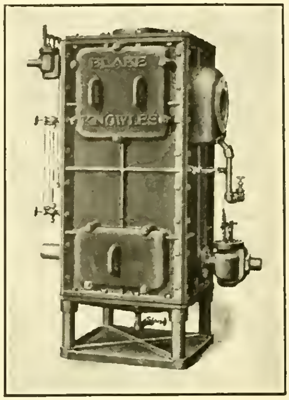


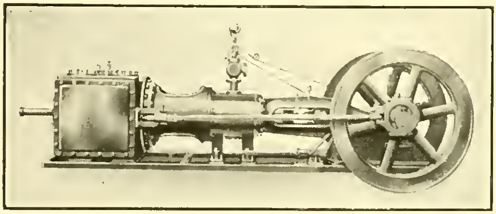
IMPROVED SIMPLEX PUMPS

For Boiler Feeding, Pressure,
Tank and Vacuum Service.
Horizontal and Vertical Patterns

FEED WATER HEATERS

Open and Closed Types





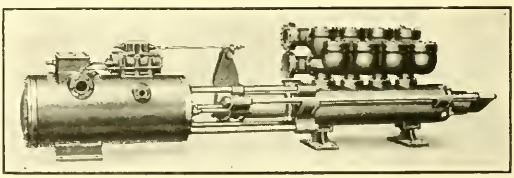
ROTATIVE DRY VACUUM PUMPS

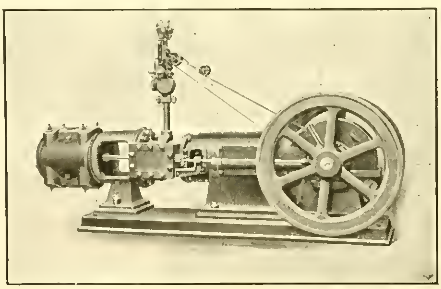
Steam and Power

For High Vacuum Service

SINGLE COMPOUND PLUNGER PUMPS

For Boiler Feeding,
Elevator Service, etc.





CLIMAX ENCLOSED FRAME AIR COMPRESSORS

Single and Duplex: Steam or Power Driven

Branch Offices in all Principal Cities

B244.S

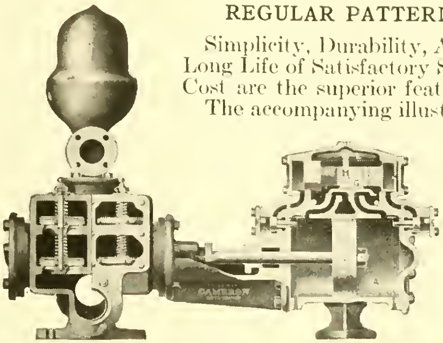
A. S. CAMERON STEAM PUMP WORKS

11 Broadway, NEW YORK

DESIGNERS AND BUILDERS OF SIMPLEX AND COMPOUND, PISTON AND PLUNGER, MARINE, PRESSURE, AIR AND VACUUM STEAM PUMPS; SURFACE AND JET CONDENSERS; CENTRIFUGAL AND TRIPLEX ELECTRIC PUMPS FOR ALL SERVICES

REGULAR PATTERN FOR GENERAL SERVICE

Simplicity, Durability, Absence of Outside Valve Gear, and Long Life of Satisfactory Service at the Lowest Maintenance Cost are the superior features of Cameron Steam Pumps.



Sectional View of Cameron Regular Pattern

The accompanying illustration shows the simple design and compact construction of the Cameron Regular Pattern Pump. It has fewer working parts than any other steam pump.

The Steam Mechanism consists of four stout pieces only, none of them delicate, intricate or exposed to injury. While under full pressure of steam the suction pipe may be lifted out of the water, and the pump allowed to run at full speed with less danger of the piston striking the cylinder heads, than any other pump made.

The Steam Valve Movement works in line with the main piston without the aid of arms or levers. There are no rods or tappet bars to get damaged or cause trouble. For this reason the Cameron can be run at a higher speed, and consequent greater capacity.

The Cameron will not reverse until the full stroke is completed, which insures maximum capacity and reduces wear.

These features, plus excellence of material and workmanship, have gained for the CAMERON a world wide reputation for Efficiency and Economy.

SIZES AND CAPACITIES OF CAMERON REGULAR PATTERN

Size Number	Diameter of Steam Cylinder, Inches	Diameter of Water Cylinder, Inches	Stroke of Piston Inches	Capacity per Stroke Gallons	Capacity at Ordinary Speed per Minute Gallons	Steam Pipe	Exhaust Pipe	Suction Pipe	Discharge Pipe	Floor Space Inches	Weight
0	3½	2	4	.054	8	⅜	½	1¼	1	32 x 9	136
1	4	2	6	.081	12	⅜	½	1¼	1	40 x 10	210
2	5	2½	6	.12	18	½	¾	1½	1¼	40 x 11	260
3	6	3	7	.21	28	¾	1	2	1½	47 x 13	418
3a	6	3½	7	.29	38	¾	1	2½	2	47 x 15	435
4	7	3½	7	.29	38	¾	1	2½	2	47 x 15	459
4a	7	4	7	.39	50	¾	1	2½	2	51 x 16	457
5	7	3½	12	.5	50	1	1½	3	2½	58 x 17	820
5b	7	5	13	1.10	100	1	1½	4	3	63 x 20	1117
6	8	4	12	.65	65	1	1½	3	2½	58 x 18	864
6a	8	5	13	1.10	100	1	1½	4	3	63 x 20	1160
7	10	5	13	1.10	100	1¼	2	4	3	64 x 21	1345
8	10	6	13	1.59	150	1¼	2	4	3½	64 x 21	1411
9	12	7	13	2.16	200	1½	2½	5	4	66 x 24	1928
10a	14	8	13	2.83	261	2	3	5	5	73 x 26	2548
10	14	9	18	4.96	330	2	3	6	5	81 x 30	3126
11	16	10½	18	6.75	450	2½	4	8	6	90 x 37	4920
12	18	12	20	9.80	587	3	4	10	8	103 x 41	6080

CHICAGO PUMP COMPANY

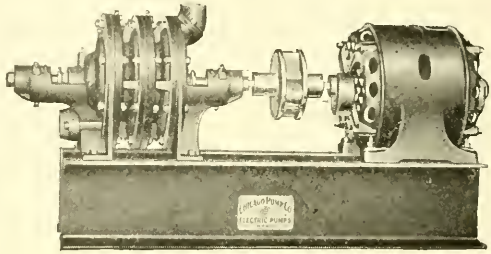
General Offices: 919 W. Lake St., CHICAGO, ILL.

MANUFACTURERS OF ELECTRIC PUMPING MACHINERY: DUPLEX ELECTRIC SEWAGE EJECTORS, AUTOMATIC ELECTRIC BILGE PUMPS, LITTLE GIANT ELECTRIC CELLAR DRAINERS, PNEUMATIC WATER SYSTEMS, MULTI-STAGE TURBINE PUMPS, ELECTRIC HOUSE SERVICE PUMPS, AUTOMATIC CONDENSATION PUMPS AND RECEIVERS.

MULTI-STAGE TURBINE PUMPS

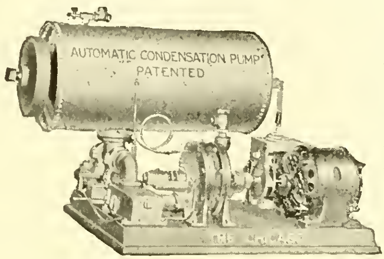
Our line of Multi-Stage Turbine Pumps that are fitted with Outer Board Ring Oiled Bearings and enclosed type balanced Impellers is complete and perfect. Capacities from 10 to 5,000 gallons per minute.

Write for full descriptive catalog.



Multi-Stage Turbine Pump

AUTOMATIC ELECTRIC CONDENSATION PUMPS AND RECEIVERS



Automatic Electric Condensation Pump and Receiver

We illustrate our "Chicago" Condensation Pump which is used for returning water of condensation into Boiler. When a given quantity of water enters tilting receiving tank, it automatically starts motor by closing automatic switch, stopping same when water has been pumped out. There are no floats or any working parts inside this receiving tank. Floats crack, due to great changes in temperature, and are objectionable.

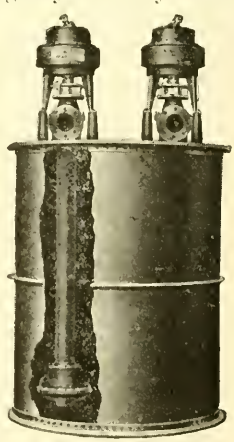
Write for catalog, which fully describes the various types of pumps we manufacture. Our engineers will gladly furnish you with copies of specifications covering any type of pump.

DUPLEX ELECTRIC SEWAGE EJECTORS AND BILGE PUMPS

are built in sizes from 10 to 500 gallons per minute. We have made the scientific construction of Sewage Ejectors our chief study, and these are the results of years of experience and observation. We have eliminated all unnecessary and complicated parts, so that we now have the simplest, most compact and durable Ejector on the market.

Recent Chicago Installations

Westminster Bldg., A. S. Alshuler, Arch.
Crane Co. Bldg., Holabird & Roche, Arch.
Blackstone Hotel, Marshall & Fox, Arch.
Advertising Bldg., W. C. Zimmerman, Arch.
University of Chicago, Shepley, Rutan & Coolidge, Arch.
Joliet Union Station, Jarvis Hunt, Arch.
Beloit College Bldg., Jenney, Mundie & Jensen, Arch.



Duplex Electric Sewage Ejector in Pit

D'OLIER CENTRIFUGAL PUMP AND MACHINE COMPANY

MORRIS BUILDING
PHILADELPHIA, PENNA.

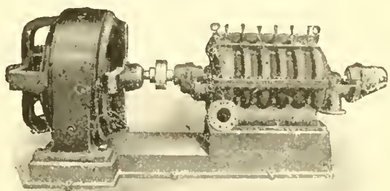
D'OLIER CENTRIFUGAL VOLUTE AND TURBINE PUMPS

FOR WATER WORKS AND IRRIGATION, FIRE SERVICE, BOILER FEED, MINE DRAINAGE, CONDENSER SUPPLY, SEWAGE, FILTRATION SYSTEMS, HYDRAULIC MINING, AND GENERAL SERVICE.

Pumps carefully designed and built for particular service required.

Complete Pumping and Power Plants installed.

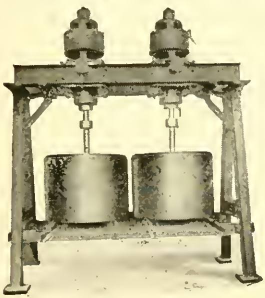
We manufacture only a high grade, high efficiency pump, using the best grade of materials throughout. The impellers are accurately designed and carefully finished, thereby insuring maximum efficiency.



6"-6 Stage D'Olier Turbine Pump.
700 G. P. M. at 700 ft. total head

D'OLIER CENTRIFUGAL MACHINES

For sugar, chemicals, sewage, oil and waste, reclaiming, clarifying and filtering and textile work. Belted, electric motor or steam turbine driven *Special Centrifugals, especially those for extreme High Speeds, designed and built.*



Standard Electric Centrifugals

STANDARD ELECTRIC CENTRIFUGALS

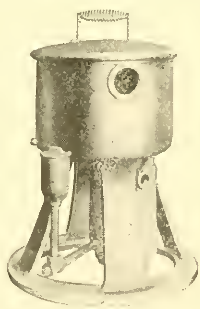
2 in battery on framing, making a self-contained unit. For sugar work, chemicals, etc. A strictly high grade machine of rugged construction; capable of results vastly superior than obtained from the belted or water driven machines formerly used.

D'OLIER COMBINED OIL EXTRACTING AND WASHING CENTRIFUGALS

For separating and reclaiming oil from wiping waste, machinery wiping towels, rags, etc.

Washing and drying waste, towels and other materials.

Recovering oil from automatic machined parts, metal chips, turnings and scrap, and like economic uses.



Combined Oil Extracting and Washing Centrifugal Machine

SEWAGE DISPOSAL PLANTS

UTILIZATION OF WASTE PRODUCTS

Highly efficient apparatus for purification of sewage, drying of sludge and the recovery of by-products.

Screens—Disc, rotating plate and bar and cylinder types.
Centrifugals for purging sludge and screenings.
Pumps for sewage and sludge. *Apparatus for recovery of values.*

Send for Catalogue

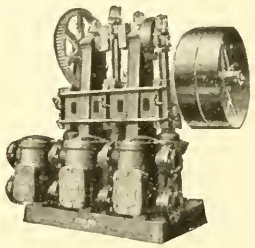
W. & B. DOUGLAS

(Established 1832)

MIDDLETOWN, CONN.

New York Warehouse and Service Dept., 83 John Street

HAND PUMPS; SPRAY PUMPS; POWER PUMPS, BELT, ELECTRIC OR GASOLENE DRIVEN, FOR ALL PURPOSES.



TRIPLEX PUMPS

Outside-packed, single acting, for water-supply, boiler-feed, elevator service, sprinkler service, brine-circulation, etc., etc.

Sizes from 2 x 3 up to 8 x 12.

Pressures up to 300 lbs. per square inch.

Described in our Bulletin No. 9.

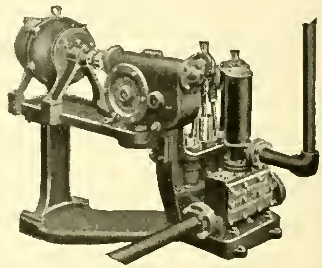
ELECTRIC TRIPLEX PUMPS

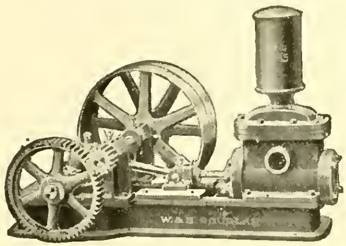
Direct-connected units, reduction either by worm-gearing, spur gearing, silent chain or endless belt with idler. Illustration shows our specialty: worm gear-case connecting a medium-speed motor with a triplex pump. We designate the combination Fig. 468. Unequalled for hotels, apartment-houses and private residences, because it is practically noiseless.

Sizes, 2 x 3, 3 x 4, 4 x 4, 4 x 6.

Pressures up to 130 lbs.

Described in our bulletin, No. 9.





HORIZONTAL PUMPS

Inside-packed, double-acting, for water-supply and handling of clear liquids. Especially adapted for long suction lifts. Electric-driven or belt driven.

Sizes, $1\frac{1}{2}$ x 3 up to 8 x 8.

Pressures up to 150 lbs.

Described in our bulletin No. 11.

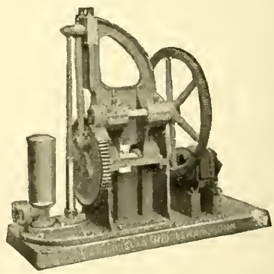
DEEP-WELL PUMPS

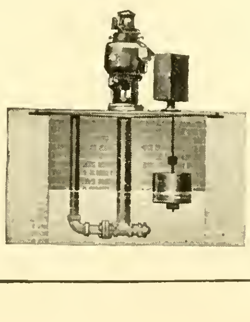
Single-acting, with or without differential plunger. Electric-driven, gasolene-driven or belt-driven. Unusually rigid, best of workmanship.

Various diameters of inlet up to 6 inches.

Plunger load up to 1500 lbs.

Described in our Catalogue "L."





CENTRIFUGAL PUMPS

For low heads. Illustration shows one of our sump outfits. These are very carefully made and tested to fit the special conditions found in each building. Covers furnished to fit any shape of pit.

Described in special sump pump bulletin, also in bulletin No. 11.

We also make low-head centrifugals for contractors' use, hand boiler test-pumps and a full line of hand pumps.

THE DEMING COMPANY

SALEM, OHIO, U. S. A.

New York Office and Stock: 152 Chambers Street

SINGLE AND DOUBLE ACTING TRIPLEX PUMPS; ARTESIAN WELL PUMPS AND CYLINDERS, FOR OPERATION BY ELECTRIC MOTORS, GAS OR GASOLINE ENGINES, OR BELT FROM SHAFT.

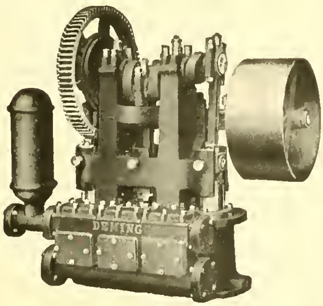


Fig. 50, Size 7 x 8 to $8\frac{1}{2}$ x 8.

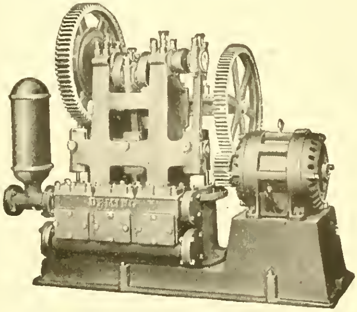


Fig. 50, Size $5\frac{1}{2}$ x 8 with Type "B" Drive.

Made in sizes from 2x2 to 13x14, with capacities of 300 gallons to 58,000 gallons per hour. For Waterworks, Boiler Feeding, General Water Supply, Etc.

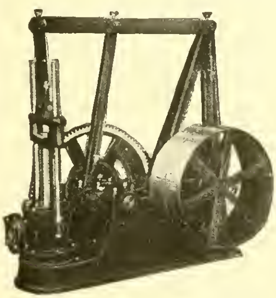


Fig 62, 10-inch Stroke.

Made in three strokes, 10, 16 and 24".
For Wells up to 300 ft. deep.

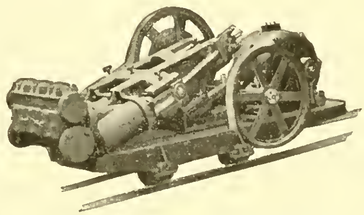
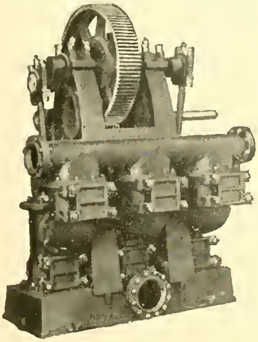


Fig. 70, 5x6, Portable Mine Pump.

Made in sizes from $3\frac{1}{2}$x4 to $8\frac{1}{2}$x8, with capacities of 1,800 gallons to 18,000 gallons per hour.



Single Acting Triplex Stuff Pump for 75 lbs. Maximum Pressure.

For Handling Paper Stock and Thick Liquids. Made in sizes from 4x6 to 11x12.

Complete
192 Page
Power Pump
Catalogue
Mailed to
Engineers
on Application.

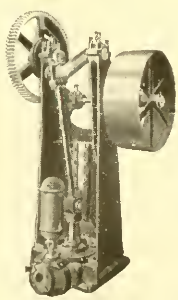


Fig. 80, Deep Well Power Working Head with Differential Plunger.

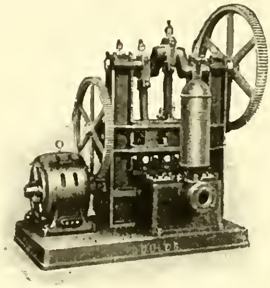
16" and 24" strokes, capacities 1,000 gallons to 4,500 gallons per hour. For wells 725 ft. deep or less.

Deming Triplex Power Pumps Effect an Actual Saving of $33\frac{1}{3}\%$ over Steam Pumps.

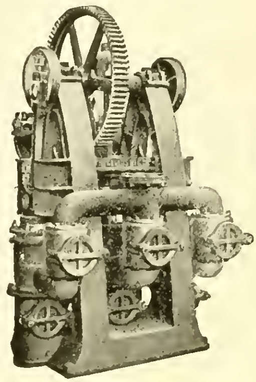
THE GOULDS MANUFACTURING CO.

SENECA FALLS, N. Y.

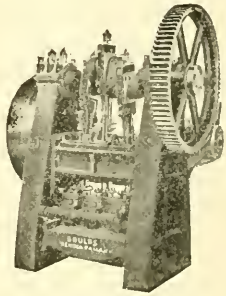
PUMPS FOR EVERY SERVICE



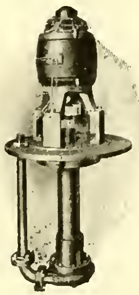
Single-Acting Triplex Pump



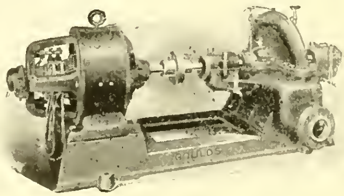
Stuff Pump



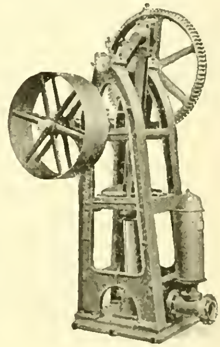
Triplex Pressure Pump



Centrifugal Sump Pump



Single-stage, Double-suction Centrifugal Pump

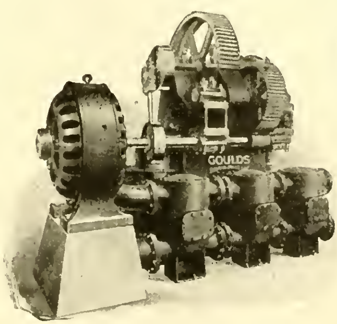


Deep Well Working Head

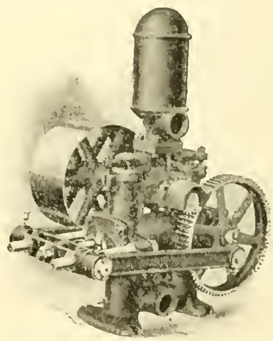
Ask for bulletins on Power or Hand Pumps for any service in which you are interested.

GOULDS PUMPS

FOR EVERY SERVICE



Double-Acting Triplex Pump

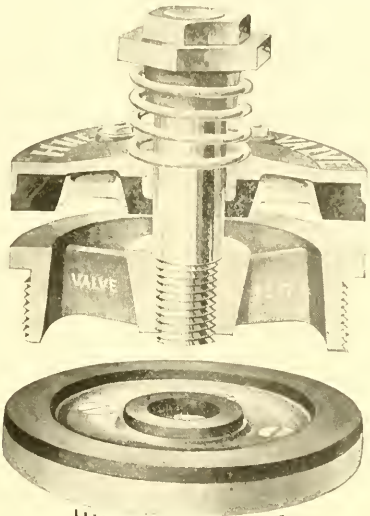


Double-Acting Single Cylinder Pump

THE HILL PUMP VALVE CO.

CHICAGO, ILL.

HILL PUMP VALVES FOR BOILER FEED, VACUUM, ELEVATOR AND MINE PUMPS, PUMPING ENGINES, TAR, OIL AND BRINE PUMPS.



Hill valves remain efficient, always seal tight, wear evenly and cannot ride on the bridges.

Pumps equipped with this type of valve give highest possible efficiency and capacity and continue to do so.

It has been found that the installation of Hill Valves increases a pump's efficiency from 10 to 50%.

Made in all sizes from 2″ to 8″ diameter.

CONSTRUCTION

The construction of this valve is shown in the cut. The valve consists of a bronze body carrying two composition seal rings, the seal rings being retained in place by the outer and inner lips of the body and by a concentric wedge ring. The body has a central sleeve bearing which fits loosely on the stem. The inner ring does not come in contact with the stem. The binder ring is bronze and is held to the valve body by brass screws and lock nuts. All similar parts of valves of the same size and type are interchangeable.

The valve seat has three ribs except in the larger sizes. The ribs of the seat are not required to support the valve and thus the lesser number increase the area of the waterway, and greatly decrease the friction. The bridges are machined below the seating surface so that the water stands above them even when the valve is on its seat.

The valve stems are Tobin bronze. The upper end is threaded for the spring cap and lock nut. The spring cap is grooved to center the spring.

The spring is made of a superior grade of bronze wire of suitable tension to seat the valve properly.

The lift of the valve is such as to give a free waterway area equal to or slightly in excess of the free waterway area of the seat.

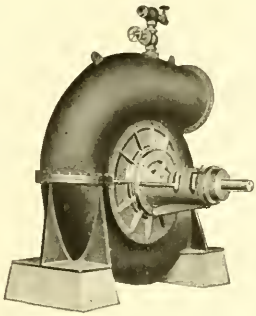
Many pumps have seats which conform sufficiently to the Hill Valve to obviate the necessity of changing seats.

For further information address the Hill Pump Valve Co., Chicago.

MORRIS MACHINE WORKS

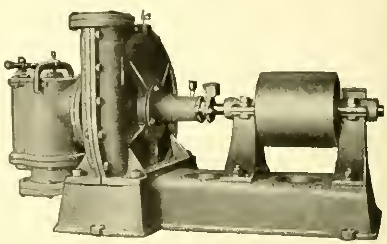
BALDWINSVILLE, N. Y.

CENTRIFUGAL PUMPING MACHINERY, STATIONARY AND MARINE ENGINES AND HYDRAULIC DREDGES.



Morris Centrifugal Pumps are simple in construction: they have only rotary parts, perfectly balanced, no reciprocating parts or valves; require small space and foundation; have high efficiency; are equally suitable for small up to very large capacities, and can handle sand or solids with the water without injury. These pumps direct connected to reciprocating engines are suitable for moderate heads, or direct connected to electric motor or steam turbine (or belt driven) for high heads. For heads above 100 feet, pumps are preferably built in stages.

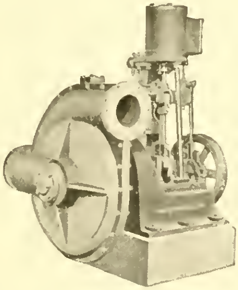
When making inquiries for pumps, full information should be given—that is, quantity of water desired, head, including friction (or give actual elevation and length of suction and discharge piping), type of pump desired, how driven—whether belt, steam engine, electric motor (give electric current characteristics), arrangement of suction and discharge openings desired, whether right hand or left hand, etc.

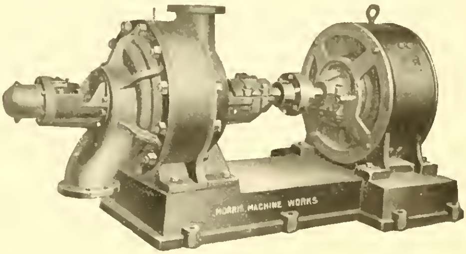


MORRIS IMPROVED STANDARD IRON HORIZONTAL PUMP.

No. Pump (Diameter Discharge Opening)	Size Pipe Flange on Suction, Inches	Economical Capacity, for each Gallons per Minute	Horse-Power Required Pulley, Foot Head	Diameter and Face of Pulley in Inches	Floor Space Required in Inches, Without Primer	Shipping Weight Without Primer, Lbs.	Shipping Weight With Primer, Lbs.	No. Pump
1½	2	70	.058	6 x 6	17 x 31	175	220	1½
1¾	2	90	.075	7 x 8	21 x 32	260	305	1¾
2	3	120	.10	8 x 8	23 x 37	350	415	2
2½	3	180	.15	8 x 8	24 x 38	360	430	2½
3	4	260	.22	8 x 8	25 x 39	415	495	3
4	5	470	.30	10 x 10	29 x 41	615	720	4
5	6	735	.45	12 x 12	34 x 54	940	1075	5
6	8	1050	.59	15 x 12	37 x 55	1180	1345	6
8	10	2000	1.00	20 x 12	45 x 64	2065	2430	8
10	12	3000	1.52	24 x 12	51 x 69	2610	2940	10
12	15	4200	2.00	30 x 14	63 x 71	3615	....	12
15	18	7000	3.50	40 x 15	77 x 80	7100	....	15
15	18	7000	3.50	30 x 15	60 x 68	3150	....	15
18	20	10000	4.50	40 x 16	93 x 103	9000	....	18
18	20	10000	4.50	30 x 16	66 x 72	4835	....	18
20	22	12000	5.40	36 x 20	73 x 83	6800	....	20
24	24	15000	6.50	48 x 36	94 x 137	....	....	24

MORRIS MACHINE WORKS





We build CENTRIFUGAL PUMPS for almost any service and of all types, including side suction and double suction, vertical or horizontal shaft. STAGE PUMPS for high heads. TWIN PUMPS for large capacities and high speeds. Or will design SPECIAL PUMPS to suit special conditions. We also build a very complete line of STATIONARY AND MARINE ENGINES, in single cylinder, compound and triple expansion types.

DREDGING PUMPS

MORRIS Dredging Pumps are made in sizes from 2″ discharge and upward, both lined and unlined. They are belt driven or direct connected to steam engines. We can furnish pumps only or the complete dredge, including all machinery.

20″ HYDRAULIC DREDGE with 750 H. P. MORRIS Triple Expansion Engine, Water Tube Boilers, Cutter Machinery. This Size Dredge Has an Average Capacity of 250,000 Cubic Yards of Material per Month.

R. D. WOOD & COMPANY

PHILADELPHIA, PA.

ENGINEERS, IRON FOUNDERS, MACHINISTS:—WATER AND GAS WORKS APPLIANCES, AND PUMPING MACHINERY; CAST IRON PIPE; GAS HOLDERS, PURIFIERS, CONDENSERS, COAL GAS PLANTS; HYDRAULIC TOOLS AND MACHINERY, PUMPING ENGINES, CENTRIFUGAL PUMPS; GAS PRODUCERS, GAS PRODUCER PLANTS FOR POWER, FUEL AND METALLURGICAL PURPOSES, THEISEN WASHERS; GENERAL MACHINERY, LARGE LOAM CASTINGS; SUGAR HOUSE APPARATUS; VALVES AND HYDRANTS.

CAST IRON PIPE

Bell and Spigot Pipe from 1 inch to 84 inches in diameter, Flange, Special deep bell, High Pressure, Flexible joint for Submarine Work, Standard and Special Fittings, Heavy Loam and Dry Sand Castings.

PUMPING ENGINES

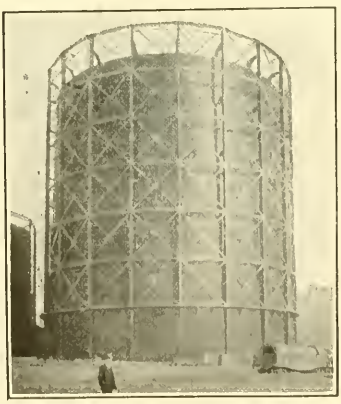
Vertical Triple Expansion, and Direct Acting for Water Works, Sewage, Irrigation and for high pressures. High duty pumping engines of both the crank and fly wheel and direct-acting types. Designed to combine highest economic duty and efficiency with greatest reliability and utmost simplicity.

Estimates and drawings (either exact or preliminary) furnished upon application, with statement of requirements to be fulfilled.

CENTRIFUGAL PUMPS

For Water Works, High Pressure Fire Systems, Irrigation Reclamation, Dredging, Sewage, etc.

Superior in Design—High Efficiency—Reliable Service.



Gas Holders—Single or Multiple Lift—any Capacity.

Heavy Tank and Plate Work.

Purifiers, Scrubbers, Condensers, Gas Works Appliances.

Coal Gas Plants.

Bench Work, Center Seals.

Gas Valves.

R. D. WOOD & COMPANY

HYDRAULIC MACHINERY

Hydraulic Presses of every description for the heaviest work, Steam Hydraulic Forging Presses, Punches, Shears, Riveters, Intensifiers, Hoists, Pressure Pumps, Cranes, Valves, etc., etc. For the majority of operations to which hydraulic power can be applied, and especially those requiring very great force exerted through a comparatively short stroke, as in riveting, punching, shearing, lifting, forging and flanging, there is no other system at all comparable with it for efficiency, uniformity, simplicity or economy. This is true for several reasons; primarily in that there is absolutely no motion or power consumed except in the act and at the moment of performing the desired operation.

HYDRAULIC VALVES

Hydraulic Operating Valves, Check, Foot, Stop and Shock Relief Valves

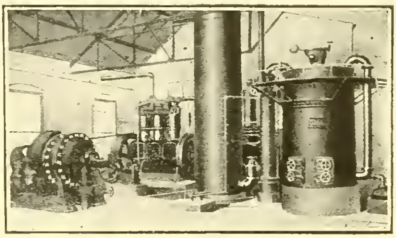
A high grade valve is an essential to the satisfactory operation of hydraulic machinery.

We are building a patented type of operating valve which is giving excellent service. We have also a special line of Check, Foot, Stop and Shock Relief Valves.

PRODUCER GAS PLANTS

We have had years of experience in the building of producers for all kinds of fuel purposes as well as for power, and our customers may be certain of securing apparatus suitable to their requirements both from an economic and operating standpoint.

Our engineering department is at your service, and we would be pleased to have our representative visit your plant and give full details.



GAS WASHERS

We control for the United States the Theisen Gas Washing Process, which we build for producer and blast furnace gas. This Process was adopted by the United States Steel Company at Gary, and is being put in with all their new construction. It delivers the gas to an engine cleaner than the air in the mixture.

GENERAL MACHINERY

Our shops are well equipped for building large machinery of every description, such as sugar, chemical and similar work.

IRON CASTINGS

We are especially well equipped for making large and intricate loam castings; also castings in dry sand and green sand.

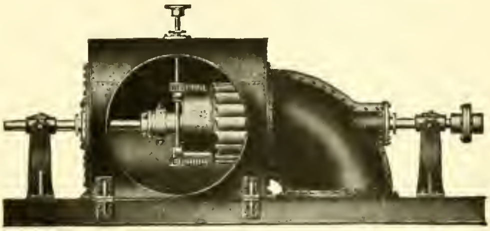
HYDRANTS AND VALVES

Fire Hydrants, Mathews patents for standard and high pressure. Gate, Check, Foot and Air Valves, Valve Boxes, Indicator Posts, Foot Valve and Intake Screens, Flood Racks, etc.

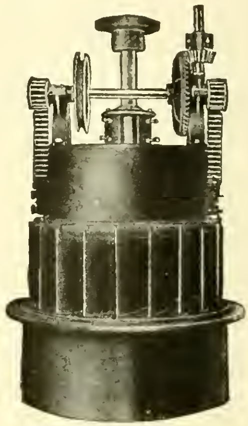
J. & W. JOLLY

HOLYOKE, MASS., U. S. A.

HORIZONTAL AND VERTICAL TURBINES



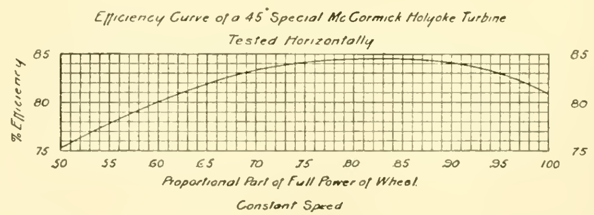
McCormick Cylinder Gate Turbines, Horizontal Type, in Steel Flume



McCormick Vertical Turbines

We build turbines in all sizes and styles, both cylinder and swing gates, to meet ordinary conditions, and design new wheels to meet special conditions of power and speed. We guarantee results in all cases. We would call particular attention to the efficiency curve shown below, which was plotted from results shown by the official test sheet. This wheel, when tested in the flume of the Holyoke Water Power Co., was mounted on a horizontal shaft, and discharged through a quarter-turn elbow and draft tube, thus giving results under actual working conditions.

Note that constant speed is maintained at all stages of power.



We also build Headgates complete with operating mechanisms of various designs for gates opening either vertically or horizontally.

THE DUFF MANUFACTURING CO.

N. S. PITTSBURG, PA., U. S. A.

GENUINE BARRETT JACKS; DUFF BALL-BEARING SCREW JACKS; DUFF-BETHLEHEM FORGED STEEL HYDRAULIC JACKS; GEARED RATCHET LEVER JACKS; AUTOMOBILE JACKS; TELESCOPE SCREW JACKS; OIL WELL JACKS; PIPE FORCING JACKS; MOTOR ARMATURE LIFTS, ETC.

BARRETT TRACK AND AUTOMATIC LOWERING JACKS.

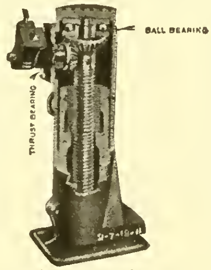
are made both single and double acting, in every type and size—for every purpose, ranging in capacity from ¾ to 20 tons.

They are quick acting, positive and durable, and will operate on continuous work at low maintenance cost.

They comprise the most popular line of lifting jacks in the world and are recognized as the standard by all leading railroads.

DUFF BALL-BEARING GEARED SCREW JACKS.

Are constructed of refined malleable iron and steel. All gears are of high carbon steel, drop forged, and have machine-cut teeth.



Sectional View

The load is carried on a large ball bearing of special design, reducing friction to an absolute minimum. The thrust on the bevel pinion is taken by another anti-friction bearing, an exclusive feature. Made in all sizes and capacities ranging from 10 tons to 75 tons.

THE DUFF-BETHLEHEM FORGED STEEL HYDRAULIC JACKS

Forged entirely out of steel—the latest and highest development in Hydraulic Jacks, they are more powerful, yet from 30 to 60% lighter than any other Hydraulic Jacks.


Sectional View

The design embodies no joints, few packings and but a third the number of parts of other jacks of similar type.

These jacks cause no trouble, are used at any angle, and operate at low cost under continuous service.

Made in 101 sizes and capacities, ranging from 10 to 500 tons.

COMPLETE INFORMATION.

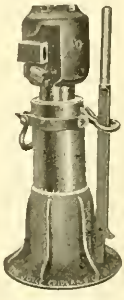
Concerning the above and other types of lifting jacks may be secured by addressing this company.

THE JOYCE-CRIDLAND CO.

DAYTON, OHIO

MANUFACTURERS OF ALL STYLES OF LIFTING JACKS: HYDRAULIC, LEVER, AUTOMATIC, GEARED AUTOMATIC, SCREW, TRAVERSING, JOURNAL, ETC.

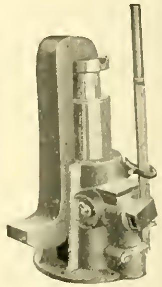
HYDRAULIC JACKS



Inside Pump Type

"J-C" Hydraulic Jacks have a wide range in ratios of ram area to pump plunger area and large handle leverage, permitting one man to lift up to several hundred tons without severe exertion. Can be let down as slowly or as rapidly as desired. Cylinders and ram are forged from solid bar of steel, and sliding surfaces contain no welds or seams to impair contact. Special provision made for preventing leakage and undue wear—there is easy access to suction and discharge valves in pump block. All delicate surfaces are protected from grit. Jacks have safety stop to prevent ram being pumped beyond its limit. Speeding devices to work ram up to load quickly.

Our Hydraulic Jacks are made in two types. The INSIDE PUMP type consists essentially of two telescoping hollow steel cylinders, the inner one furnishing the cistern and the recess for the pump. This type is very light and compact, and absolutely reliable under all loads up to rated capacity. In the OUTSIDE PUMP type, the pump occupies a fixed position at one side of the cylinder, and the operating lever always swings in a fixed center. This type is more suitable for higher tonnages.



Outside Pump Type

INSIDE PUMP TYPE

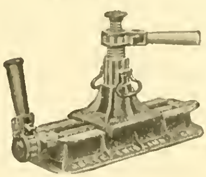
Jack No.	Capacity, Tons	Rise, Ins.	Ht. when Down, Ins.	Weight, Pounds
412BB	4	12	23⅛	60
418BB	4	18	29⅛	68
424BB	4	24	35⅛	74
709BB	7	9	21	69
712BB	7	12	24	75
718BB	7	18	29⅝	87
724BB	7	24	36	99
1006BB	10	6	19⅝	81
1009BB	10	9	22¼	89
1012BB	10	12	25¾	97
1018BB	10	18	31¼	112
1024BB	10	24	37¼	128
1512BB	15	12	25½	125
1518BB	15	18	32¾	137
1524BB	15	24	38⅞	163
2012BB	20	12	25⅝	129
2018BB	20	18	33	161
2024BB	20	24	38⅝	181
3009BB	30	9	24¼	189
3012BB	30	12	26¾	205
3018BB	30	18	33⅜	230
3024BB	30	24	39⅜	265
4009BB	40	9	24⅜	191
4012BB	40	12	27⅜	214
4018BB	40	18	33⅜	249
4024BB	40	24	40	294
6009BB	60	9	24	228
6012BB	60	12	27	240
6018BB	60	18	33	264

OUTSIDE PUMP TYPE

Single Pump					Double Pump				
Jack No.	Capacity, Tons	Rise, Ins.	Ht. when Down, Ins.	Weight, Pounds	Jack No.	Capacity, Tons	Rise, Ins.	Ht. when Down, Ins.	Weight, Pounds
3006OSP	30	6	13¾	184	3006ODP	30	6	13¾	184
3009OSP	30	9	16¾	201	3009ODP	30	9	16¾	204
3012OSP	30	12	20¼	241	3012ODP	30	12	20¼	241
3018OSP	30	18	25¾	259	3018ODP	30	18	25¾	259
3024OSP	30	24	31¾	304	3024ODP	30	24	31¾	304
4006OSP	40	6	14⅛	200	4006ODP	40	6	14⅛	200
4009OSP	40	9	17⅛	222	4009ODP	40	9	17⅛	222
4012OSP	40	12	20⅛	244	4012ODP	40	12	20⅛	244
4018OSP	40	18	26⅜	288	4018ODP	40	18	26⅜	288
4024OSP	40	24	32⅛	332	4024ODP	40	24	32⅛	332
6009OSP	60	9	18⅛	268	6009ODP	60	9	18⅛	268
6012OSP	60	12	20¼	313	6012ODP	60	12	20¼	313
6018OSP	60	18	26¾	353	6018ODP	60	18	26¾	353
8009OSP	80	9	18½	357	8009ODP	80	9	18½	357
8012OSP	80	12	21	394	8012ODP	80	12	21	394
8018OSP	80	18	27½	469	8018ODP	80	18	27½	469
10009OSP	100	9	19¼	450	10009ODP	100	9	19¼	450
10012OSP	100	12	22¼	495	10012ODP	100	12	22¼	495
10018OSP	100	18	29¼	596	10018ODP	100	18	29¼	596
15009OSP	150	9	20	500	15009ODP	150	9	20	500
15012OSP	150	12	23	550	15012ODP	150	12	23	550
15018OSP	150	18	30⅝	750	15018ODP	150	18	30⅝	750
20012OSP	200	12	25	750	20012ODP	200	12	25	750

TRAVERSING JACKS

These are our regular screw jacks with bottoms of special design and fitted to traversing bases. The main parts are of malleable iron and the screws of machinery steel.



Jack No.	37	37a	60	60a	35	41	36	42
Height when Down, Ins.	15	15	18	18	27	30½	23	26
Height of Base, Ins.	3½	3½	3½	3½	3½	4¾	3½	4¾
Rise of Screw, Ins.	10	10	14	14	10	11	10	12
Horizontal Movement, Ins.	15	15	15	15	15	15	15	15
Weight of Jack, Pounds	137	115	149	135	172	300	143	280
Capacity, Tons	8	8	15	15	25	50	25	50

THE JOYCE-CRIDLAND CO.

PLAIN LEVER JACKS

These Jacks are especially suited for small and medium loads where the jack must be applied in various different ways, and under rugged conditions.

Jack No.	Height when Down, Ins.	Rise of Bar, Ins.	Size of Bar, Ins. (Square)	Weight of Jack, Pounds	Capacity, Tons
1a	16	8¼	1¼	24	2
2a	18½	10	1¼	28	2
3	11½	4	1½	27	4
4	22½	14	1½	40	4
4a	18½	10½	1½	37	4
4e	41½	35	1½	60	4
4f	36	30	1½	55	4
6	26½	14	2	92	15
7	35	25½	2	115	15
10	27	16	1¾	76	10
10a	22½	11½	1¾	63	10

Plain Lever Jack

FULL AUTOMATIC LEVER AND GEARED JACKS

Full Automatic Lever Jacks are full automatic in raising and lowering, action being controlled by reversing lever on outside of frame. They are composed of few working parts and are more powerful than any type of plain lever jacks.

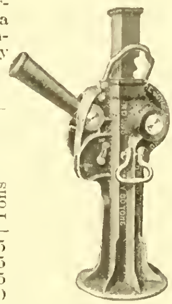
In the Full Automatic Geared Jacks, by means of a gear and pinion, interposed between the lever and lifting bar, one can lift with the same effort a weight four times as great as with a plain lever jack. This jack is of the simplest possible construction considering its full automatic features. For heavy service and severe usage.

AUTOMATIC LEVER JACKS

Jack No.	Ht. of Bar, Down, Ins.	Rise of Bar, Ins.	Size of Bar, Ins. (Sq.)	Weight, Pounds	Capacity, Tons
66	13½	6½	1¼	33	4
67	16	8	1¼	34	4
68	19	11	1¼	39	4
*74	11	5	1½	35	10
76	22¼	14¼	1½	54	10
80	22	10	1¾	80	12
81	27	15	1¾	88	12
84	22	12	2	90	15
85	26½	16	2	105	15
86	36	25	2	128	15

AUTOMATIC GEARED JACKS

Jack No.	Ht. when Down, Ins.	Rise of Bar, Ins.	Rise per Str. of Lever, Ins.	Size of Bar, Ins.	Weight, Pounds	Capacity, Tons
293	24	14	⅛	2½x3	175	35
295	27	17	⅛	2½x3	190	35
296	33	23	⅛	2½x3	215	35
397	22	12	⅛	3 x3	250	50
398	24	14	⅛	3 x3	260	50
399	25⅝	15½	⅛	3 x3	265	50
400	27¼	17	⅛	3 3x	268	50
401	36	26	⅛	3 x3	300	50
402	31	21	⅛	3 x3	282	50



Full Automatic Geared Jack

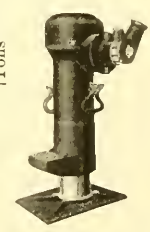
*This jack is shortened for journal box work.

GEARED SCREW JACKS

The "J-C" Geared Screw Jack gives the greatest speed consistent with safety. Entire working parts can be removed through top of jack without taking sleeve off standard. Nut is locked, preventing it being pulled out while jack is being carried or handled, and has a positive stop which prevents screw from being run out of nut.

Jack No.	Ht. when Down, Ins.	Rise of Screw, Ins.	Diam. of Screw, Ins.	Weight, Pounds	Capacity, Tons
154RB	22	13	2	114	25
154SB	"	"	"	114	"
154GL	"	"	"	119	"
155RB	26	17	2	128	25
155SB	"	"	"	128	"
155GL	"	"	"	133	"
156RB	34	25	2	157	25
156SB	"	"	"	157	"
156GL	"	"	"	162	"
157RB	20	11	2½	161	35
157SB	"	"	"	161	"
157GL	"	"	"	168	"
158RB	22	13	2½	172	35
158SB	"	"	"	172	"
158GL	"	"	"	180	"
159RB	24	15	2½	183	35
159SB	"	"	"	183	"
159GL	"	"	"	191	"
160RB	27	18	2½	200	35
160SB	"	"	"	200	"
160GL	"	"	"	208	"

Jack No.	Ht. when Down, Ins.	Rise of Screw, Ins.	Diam. of Screw, Ins.	Weight, Pounds	Capacity, Tons
161RB	30	21	2½	217	35
161SB	"	"	"	217	"
161GL	"	"	"	225	"
162RB	33	21	2½	234	35
162SB	"	"	"	234	"
162GL	"	"	"	242	"
164RB	24	13½	2¾	220	50
164SB	"	"	"	220	"
164GL	"	"	"	230	"
165RB	27½	17	2¾	243	50
165SB	"	"	"	243	"
165GL	"	"	"	253	"
166RB	31	21	2¾	267	50
166SB	"	"	"	267	"
166GL	"	"	"	277	"
168RB	38	28	2¾	314	50
170RB	27	14½	3	288	70
170SB	"	"	"	288	"
170GL	"	"	"	300	"



Geared Screw Jack, Square Base with Ground Lift

PENNSYLVANIA CRUSHER CO.

STEPHEN GIRARD BLD'G., PHILADELPHIA, PA.

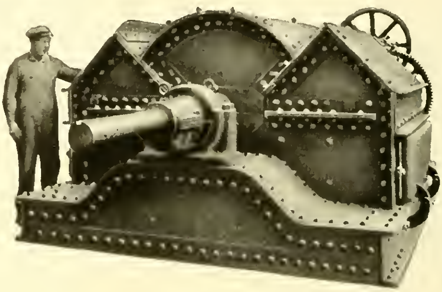
NEW YORK, 50 Church Street PITTSBURGH, Machesney Bld'g.

COAL CRUSHING & CLEANING MACHINERY FOR BY-PRODUCT COKE PLANTS, SWINGHAMMER CRUSHERS, BRADFORD COAL CLEANERS, ROTARY AND JAW CRUSHERS, SINGLE ROLL CRUSHERS, GRINDING PANS, DELAMATER "SINK & FLOAT" TESTERS.

"PENNSYLVANIA" SWINGHAMMER CRUSHERS

Extensively used for pulverizing Bituminous Coals in By-Product and Bee-Hive Coking Plants, for crushing Cement Rocks and Limestones in Cement Mills, for Lime, Shales, Bone and a multitude of other materials.

Main frame of fabricated Steel practically immune from breakage. Removable Steel Wear Liners, Ball & Socket Bearings, 6, 8 and 10 rows of Hammers, large diameter Steel Discs, quick adjustable Grinding Cage. Built in Capacities 3 tons to 400 tons hourly. By weight the "Pennsylvania" is more than 90% Steel.



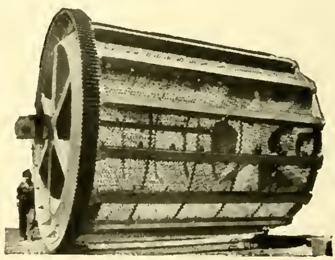
(Patented)
Hammer Crushers

"PENNSYLVANIA" BRADFORD COAL CLEANERS

For Power Houses and By-Product Coke Plants

In addition to its distinct advantages as a Crusher, this machine has the remarkable ability to *automatically* remove impurities such as slate, bone, sulphur balls or binder from bituminous steam and coking coals, thereby reducing the objectionable ash and sulphur.

It is used extensively in preparing R.O.M. coals in By-Product Coking plants and for Bee-Hive Ovens.



(Pat. applied for)
Bradford Coal Cleaner

In connection with its crushing and cleaning functions for R.O.M. coal for *large Power Houses*, the "Pennsylvania" Bradford is most efficient in removing stray iron, coupling pins, mine props and all sorts of impedimenta that damage Conveyors, Stokers and other Power House machinery.

For Stoker feed it Crushes R.O.M. *with less fines than Rolls*, or any other type.

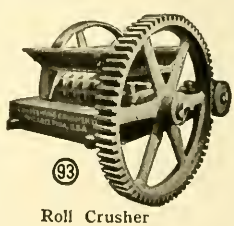
Absolutely automatic in operation, low horse power, runs 12 to 15 R.P.M., requires no labor to operate, other than occasional oiling. Is practically "fool-proof."

Several of these "Pennsylvania" Bradfords are successfully operating in connection with Coal Washers.

"PENNSYLVANIA" SINGLE ROLL CRUSHERS

Will take large pieces of Coal, Coke, Iron Ore, Limestone, Phosphate, Gypsum, Flint Clay and reduce to one inch and finer in one operation. A good machine for crushing coal for Stokers.

A single roll revolving close to a quickly adjustable breaker plate, in place of two rolls commonly used. Roll is heavily back geared and rigidly held in its bearings to *prevent spreading when feeding large lumps.* No automatic Feeder necessary. This design is smoother running than the double Roll.



(93)

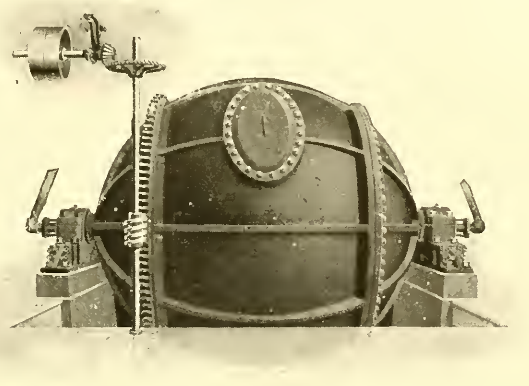
Roll Crusher

Bed frame in one piece and very rigid. Cut shows rear panel removed, exposing roll. Different designs of roll teeth are made. Moderate H. P., slow speed.

THE HOOVEN, OWENS, RENTSCHLER COMPANY

HAMILTON, OHIO

SUGAR MACHINERY, CAST IRON GLOBE DIGESTERS AND COOKERS FOR PAPER MILLS AND BLEACHERIES, PLATE GLASS FINISHING MACHINERY, SEMI-STEEL, STEEL RE-INFORCED ANVIL BLOCKS, FLEXIBLE COUPLINGS, AND SPECIAL HEAVY CAST IRON CASTINGS



Globe Digester and Cooker

The cast iron Globe Digester and Cooker is made in sizes up to and including 12 feet in diameter and is equipped with adjustable babbitted trunnion bearings. The drive may be from the ceiling hangers, as shown in illustration, or from beneath the floor—at the option of purchaser.

The Anvil Blocks are made in any size and arranged to accommodate any make of hammer. They are composed of a special mixture of semi-steel and thoroughly steel-re-inforced by the HAMILTON process.

Re-Inforced Anvil Block

The Sugar Mill Housing shown is thoroughly triangular bolt bound, and of such design that the completed housing is of maximum possible strength in every direction. This illustration shows more plainly than any description its excellent design for resisting the enormous pressures to which it is subject.

86" Semi-Steel Low Pressure Cylinder

The 86" Cylinder illustrated is a good example of our large semi-steel castings and proves that we have excellent facilities for making cast iron or semi-steel castings of any size and weight consistent with modern foundry practice.

Sugar Mill Housing

M. D. KNOWLTON CO.

Main Office and Works

24 ELIZABETH ST., ROCHESTER, N. Y., U.S.A.

NEW YORK LONDON CHICAGO

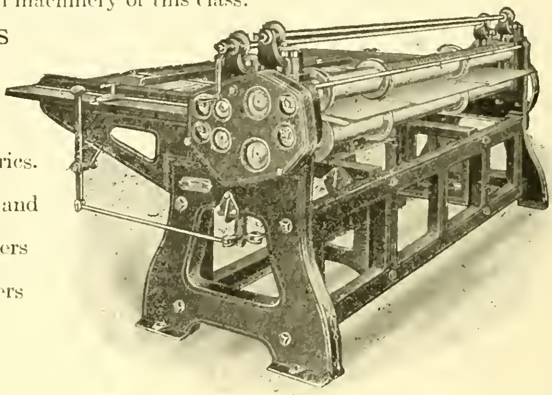
PAPER BOX AND SHIPPING CASE MACHINERY

MACHINES FOR CUTTING, TREATING AND FORMING, PAPER BOARD AND SHEET FABRICS.

Our experience in designing and making machines for this class of work extends over a period of thirty years. Our shop facilities are excellent. Many of the machines we manufacture are necessary to other industries as well as to that of the paper box. Below is only a partial list of the standard and automatic machines we manufacture and carry in stock. We solicit inquiries for standard and special machinery of this class.

CUTTING MACHINES

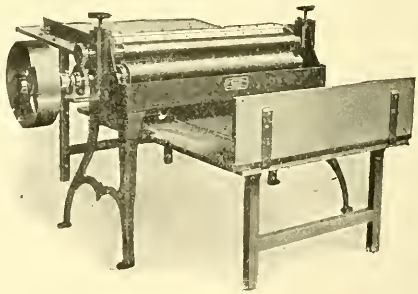
for Slitting, Sheeting or Shape Cutting, Paper, Pulp, Fibre or Corrugated Board and Sheet Fabrics.
Scorers
Rotary Paper Slitters and Rewinders
Rotary Cardboard Slitters
Corner Cutters
Slotters and Flap Cutters
Folding Box Slotters
Roll Sheet Cutters
Neck Choppers
Thumbhole Machines
Skiving Machines
Round and Oval Cutters
Rotary Cutting Knives



Heavy Rotary Slitter for Fibre and Corrugated Board

TREATING MACHINES

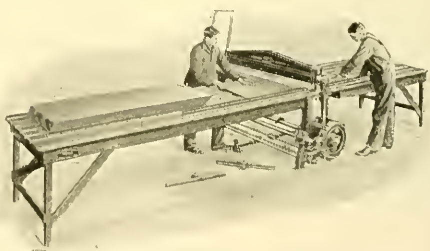
for Coating Paper and Cardboard with Glue, Silicate of Soda, Paste and other Liquid Solutions.
Automatic Gumming Machines
Plain Gumming Machines
Sheet Gluers
Sheet Pasters
Flange Gluers
Folding Box Gluers
Paraffine Coaters
Silicate of Soda Coaters
Glue Cookers and Mixers
Glue Pots



Paraffine Coating Machine

FORMING MACHINES

for Creasing, Bending and Shaping Paper and Cardboard.
Automatic Creasers and Slotters
Folding Box Creasers
Flange Benders
Plain Corner Stayers
Turn-in Corner Stayers
Ender and Corner Stayers
Tape Stayers
Covering Machines
Topping Machines
Trimming Machines



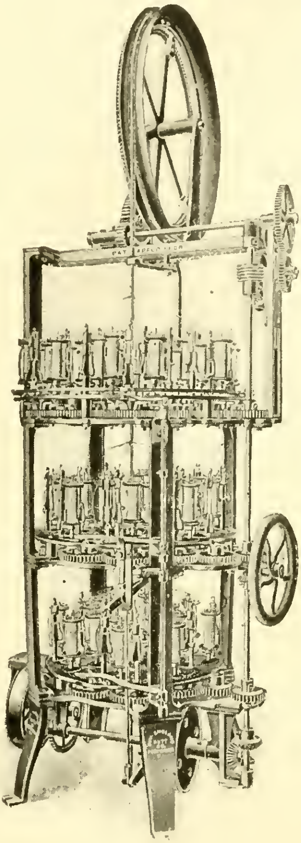
Straight Bar Creaser for Fibre and Corrugated Board

NEW ENGLAND BUTT COMPANY

PROVIDENCE, R. I.

European Agents: Selson Engineering Company, Ltd., London, England

MANUFACTURERS OF BRAIDING MACHINERY; MACHINERY FOR INSULATING WIRES AND CABLES.



Triple Deck 16x20x24.
No. 1 Cable Braider.

BRAIDING MACHINERY

American and German Type

Used for making plain and fancy braids for dress trimmings and millinery, round and flat shoe laces, soutache braids, candle wicking, tapes, cords, banding, clothes lines, fish lines, packing, gas tubing and rubber hose, round and flat elastic.

Sash Cord Braiders for making solid sash and curtain cord of various sizes.

Sash Cord Finishers for polishing solid sash cord.

Silk Covering Machines for covering cotton with silk.

Braid Spooling and Measuring Machines.

Rubber Spreading Machines, built of any desired width for applying a thin coating of rubber to cloth.

INSULATING MACHINERY.

Single, Double and Triple Deck Braiders.

These are made in all sizes and combinations for covering wires from small sizes up to large cables.

Magnet Wire Machinery for silk and cotton covering arranged to handle round and flat wires.

Annunciator Wire Winders, Single, Double or Triple Deck.

Taping Machinery for taping wires or cables with paper or other materials.

Polishing Machines, for insulated wires and cables from the small sizes up to 3″ cables.

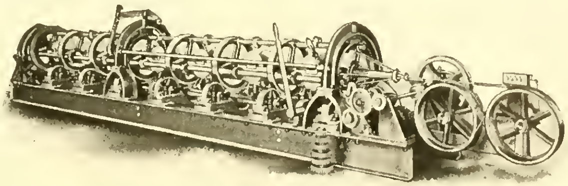
Wire Measuring Machines.

Twinning Machines.

Rubber Strip Covering Machines, for applying rubber insulation to wires and cables with either single or double seam. These machines are built in several sizes and handle from one up to twenty wires at a time.

NEW ENGLAND BUTT COMPANY

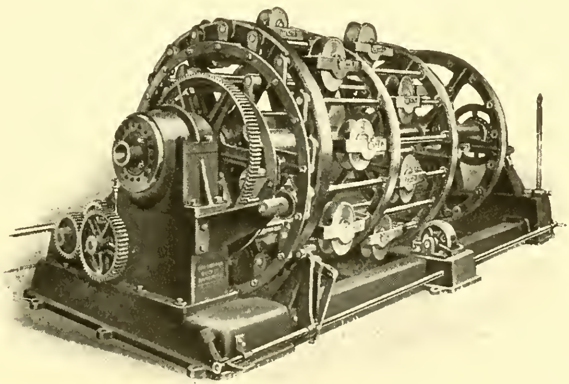
MACHINERY FOR THE MANUFACTURE OF WIRE ROPES AND CABLES



7 REEL HIGH SPEED STRANDING MACHINE.

In this type of machine the reels are carried in stationary cradles hanging at the center of the machine and the frame revolves about them.

By this construction, the machine being perfectly balanced, a very high speed is attainable. It is built in several sizes from small machines, for making the initial strands of small wire ropes, up to large laying machines holding 2000 lbs. to each reel. It is also built for making 19 wire strand.



24 REEL HORIZONTAL CABLING MACHINE.

This machine is of the planetary type in which the reels are kept in a vertical position by means of cranks and an eccentric ring at the rear of the machine.

It is built in single heads or in tandem form with any combination of heads and is used for making cables of concentric strand and also for armoring cables.

We are prepared to furnish this type of machine in a large variety of sizes.

Take up Fixtures for the above machines are built in either the single drum or the double grooved drum types.

Wind up Reel Fixtures with automatic and adjustable traverse motions can be furnished suitable to handle any size of reels.

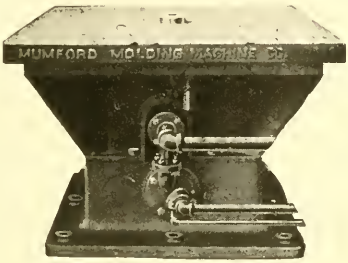
VULCAN ENGINEERING SALES CO.

2007 Fisher Bldg.
CHICAGO, ILL.

No. 30 Church St.
NEW YORK, N. Y.

CONTROLLING ENTIRE SALES AND PRODUCT

MUMFORD MOLDING MACHINE CO.



JOLT RAMMING MACHINES
Pneumatic and Electric

SPLIT PATTERN MACHINES

HAND AND POWER SQUEEZERS

PNEUMATIC VIBRATORS

FOUNDRY MOLDING MACHINERY AND EQUIPMENT

HANNA ENGINEERING WORKS

PNEUMATIC RIVETERS

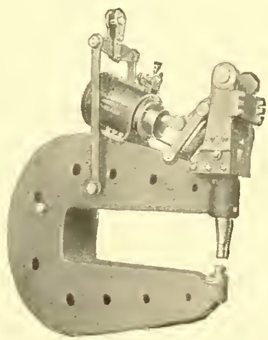
From 6 in. reach x 6 in. gap, 20 tons pressure, to 126 in. reach x 24 in. gap, 150 tons pressure.

PLAIN TOGGLE (Pinch Bug) AND COMPRESSION LEVER RIVETERS

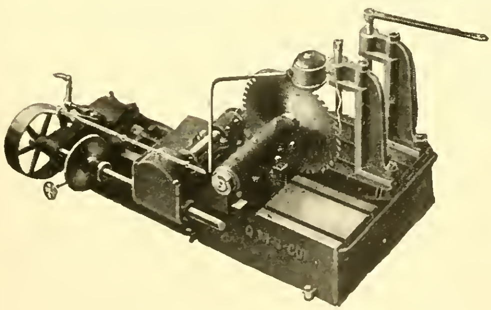
SAND SHAKERS

DUMPING RIDDLES

ELECTRIC OSCILLATORS



THE Q M S COMPANY



COLD METAL SAWING MACHINERY

Saws for Cold Cutting Off.

For Foundry, Structural and Machine Shop.

Power Hack Saws.

TRAVELING CRANES

PNEUMATIC HOISTS

I-BEAM TROLLEYS

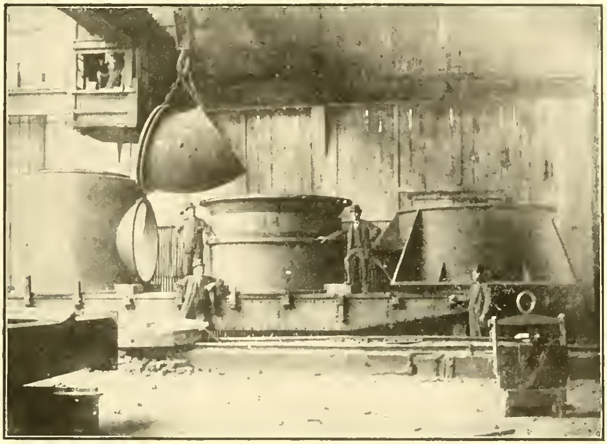
GENERAL SHOP EQUIPMENT

Complete Catalog of All Machines on Request

THE MARSHALL FOUNDRY COMPANY

PITTSBURG, PA.

INGOT MOLDS AND GREY IRON CASTINGS FOR ALL PURPOSES



Capacity 250 Tons per day

We make a specialty of large castings, such as: BLAST FURNACE CASTINGS, EVAPORATORS, CONDENSERS, SPECIAL EXHAUST OUTLETS, ETC.

CAST IRON

Ladle Linings, Cinder Pots, Kettles for Chemicals, Etc.

Our success in this line is the result of years of experience and the use of iron especially adapted for this class of work.

STRUCTURAL CAST IRON

Columns and Bases

Our facilities for production are unsurpassed, having a plant capacity of 250 tons per day.

INGOT MOLDS

Solid or Split

All kinds and sizes for Bessemer, Open Hearth or Crucible Steel.

We have on hand PATTERNS and EQUIPMENT for all sizes used in general mill work. We solicit your correspondence before placing your order.

THE KNICKERBOCKER COMPANY

JACKSON, MICH.

MANUFACTURERS OF DUST COLLECTORS AND CONCRETE MIXERS

THE MORSE RARIFIED DUST COLLECTOR

For Emery Wheels, Polishers, Sand Blast and Tumbling Mills

This Collector operates on the "Rarified" or partial vacuum principle, a constant vacuum tendency being maintained in the collector casing and a separation of the material from the air current secured *before the air reaches the fan.* In handling all products of metallic or flinty character, this feature of the "Rarified" is particularly valuable as the abrasion on the fan parts is practically eliminated, while there is no undue wear on the collector parts.

With the "Rarefied" Collector—The suction never varies, all dust heavier than air is collected, material collected is discharged automatically, there is no cleaning out by hand, there is no cloth or screens to fill up, there are no moving parts, the cost of repairs is slight.

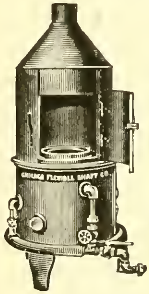
This Collector is built all galvanized sheet steel with angle iron rings. All parts riveted two inch centers. Gauge of sheet steel used depends on suction required to do the work and class of material to be handled.

The "Rarefied" must be placed ahead of the fan with the latter always exhausting to the atmosphere above the roof. Size of "Rarefied" to be used must be two numbers larger than diameter of suction pipe. If fan has 12 inch suction pipe, at least a No. 14 "Rarified" should be installed, etc.

No.	Height Top Wall	Length of Cone	Length of Trap	Height Over All	Outside Diam.	Inlet Opening	Area	Diam. Outlet leading to Fan	Diam. Dust Outlet
2	15½"	11½"	10½"	3' 1½"	15"	1¾"x 8½"	15'	2"	2"
3	18"	13½"	10½"	3' 6"	17"	2¼"x10"	22½"	3"	3"
4	20½"	15½"	10½"	3' 10½"	19"	2¾"x11½"	31½"	4"	3"
5	23"	17½"	10½"	4' 3"	21"	3¼"x13"	42"	5"	3"
6	2' 1½"	19½"	10½"	4' 7½"	1' 11"	3½"x14½"	51"	6"	3"
7	2' 4"	21½"	10½"	5' 0"	2' 1"	4" x16"	64"	7"	3"
8	2' 6½"	22"	11½"	5' 4"	2' 3"	4½"x17½"	79"	8"	4"
9	2' 10"	2' 0"	11½"	5' 9½"	2' 5"	5" x20"	100"	9"	4"
10	3' 0½"	2' 2"	11½"	6' 2"	2' 7"	5½"x21½"	118½"	10"	4"
11	3' 3"	2' 4"	11½"	6' 6½"	2' 9"	6" x23"	138"	11"	4"
12	3' 5½"	2' 5"	13"	6' 11½"	2' 11"	6½"x24½"	159½"	12"	5"
13	3' 8"	2' 7"	13"	7' 4"	3' 1"	7" x26"	182"	13"	5"
14	3' 10½"	2' 9"	13"	7' 8½"	3' 3"	7½"x27½"	206½"	14"	5"
15	4' 1"	2' 11"	13"	8' 1"	3' 5"	8" x29"	232"	15"	5"
16	4' 3½"	3' 0"	14½"	8' 4½"	3' 7"	8½"x30½"	259½"	16"	6"
17	4' 6"	3' 2"	11½"	8' 10½"	3' 9½"	9" x32"	288"	17"	6"
18	4' 8½"	3' 4"	14½"	9' 3"	3' 11½"	9½"x33½"	318½"	18"	6"
19	4' 11"	3' 6"	14½"	9' 7½"	4' 1½"	10" x35"	350"	19"	6"
20	5' 1½"	3' 7"	16"	10' 0½"	4' 3½"	10½"x36½"	383½"	20"	7"
21	5' 4"	3' 9"	16"	10' 5"	4' 5½"	11" x38"	418"	21"	7"
22	5' 6½"	3' 11"	16"	10' 9½"	4' 7½"	11½"x39½"	451½"	22"	7"
23	5' 9"	4' 0"	16"	11' 1"	4' 9½"	12" x41"	492"	23"	7"
24	5' 11½"	4' 3"	16"	11' 6½"	4' 11½"	12½"x42½"	531½"	24"	7"
25	6' 2"	4' 5"	16"	11' 11"	5' 1½"	13" x44"	572"	25"	7"
26	6' 4½"	4' 7"	16"	12' 3½"	5' 3½"	13½"x45½"	614½"	26"	7"
27	6' 7"	4' 9"	16"	12' 8"	5' 5½"	14" x47"	658"	27"	7"
28	6' 9½"	4' 10"	17½"	13' 1"	5' 7½"	14½"x48½"	703½"	28"	8"
29	7' 0½"	5' 0"	17½"	13' 6"	5' 9½"	15" x50½"	757½"	29"	8"
30	7' 3"	5' 3"	17½"	11' 0"	5' 11½"	15½"x52"	813"	30"	8"
31	7' 5½"	5' 5"	17½"	14' 4½"	6' 1½"	16" x53½"	864"	31"	8"
32	7' 7½"	5' 7"	17½"	14' 8"	6' 3½"	16½"x55"	907"	32"	8"
33	7' 10"	5' 9"	17½"	14' 11½"	6' 5½"	17" x56½"	960"	33"	8"
34	8' 0½"	5' 11"	17½"	15' 6"	6' 7½"	17½"x58"	1015"	34"	8"
35	8' 3"	6' 1"	17½"	15' 8½"	6' 9½"	18" x59½"	1071"	35"	8"
36	8' 5½"	6' 3"	17½"	16' 1"	6' 11½"	18½"x61"	1107"	36"	8"
37	8' 8"	6' 5"	17½"	16' 5½"	7' 1½"	19" x62½"	1180"	37"	8"
38	8' 10½"	6' 7"	17½"	16' 10"	7' 3½"	19½"x64"	1248"	38"	8"
39	9' 1"	6' 9"	17½"	17' 2½"	7' 5½"	20" x65½"	1310"	39"	8"
40	9' 3½"	6' 11"	17½"	17' 7"	7' 7½"	20½"x67"	1373"	40"	8"

CHICAGO FLEXIBLE SHAFT COMPANY

STEWART No. 10 CYANIDE HARDENING FURNACE



Used extensively by bank-note engravers, makers of engraved plates and transfer rolls, cutters, dies, springs, chains, and numerous other steel parts requiring hard surfaces without great depth of case. May be used for heating other chemical solutions whose fumes are poisonous and injurious to the workmen, as the hood is connected with an outside flue.

The extreme depth of case possible is obtained in 17 to 20 minutes, and an indefinitely longer contact will not add to the case—so do not waste time and fuel in longer treatments. Cyanide may be brought to a hardening heat in about 40 minutes, starting with the furnace cold, and may be kept at this heat indefinitely.

SPECIFICATIONS

Capacity No. 10 pot, 10 inches deep, 8¼ inches diameter (inside measurement).

Gas consumption, about 175 cubic feet per hour.

Price, without blower, $75.00.

Price, with blower, $115.00.

STEWART SPECIAL COMBINATION FURNACE

Oven Furnace, crucible and forge furnace, all combined on one base for economy and convenience. The forge is provided with an opening at the rear, permitting the heating of long bars, and the muffle section may be transformed into an oven furnace by removing the muffle and inserting a slab.

Price, complete, with blower, $125.00. Price, complete, without blower, $100.00

SPECIFICATIONS

Opening of oven section, 4½ in. high in center, 9 in. wide, depth 12 in.

Forge Section, 4 in. high by 5 in. wide by 10 in. deep.

Crucible—Diameter at top, 5 in.; diameter at bottom, 4 in.; depth 11 in.

Number of burners, 10.

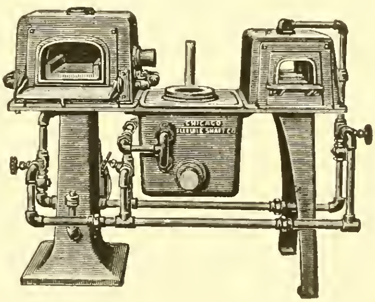
Size of gas supply pipe, 1¼ in.

Size of air supply pipe, 1¼ in.

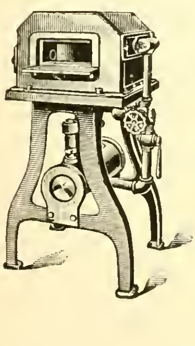
Gas consumption per hour—Crucible section about 70 cu. feet; forge section, about 60 cu. feet; muffle section, about 90 cu. feet.

Forge section will heat high speed steel.

Blowers come separate and are not attached to base.



STEWART No. 3 FORGE



For making small forgings for tool dressing, etc. Required heat is produced quickly. To reach a forging temperature takes but a minute.

SPECIFICATIONS

No. 3 FORGE—

Size of front opening, 3½x8 in.

Rear opening, 3¾ in. in diameter.

Depth, 10 in.

Gas consumption, about 80 cubic feet per hour.

Net weight, 385 lbs.

Shipping weight, 490 lbs.

Shipping case, 24x26x44 in.

No. O FORGE—

Size of front opening, 3½x5 in.

Size of rear opening, 3¾ in. diameter. Depth 7 in.

Gas consumption, about 40 cubic feet per hour.

Net weight, 285 lbs.; shipping weight, 385 lbs.

Measurements of shipping case, 42x28x20 in.

Price, with blower, $55.00; without blower, $30.00.

Complete Catalogue on request.

THE C. J. ROOT COMPANY

BRISTOL, CONN.

AUTOMATIC COUNTERS, WROUGHT BRASS HINGES, METAL STAMPINGS, ETC.

Bristol Counter

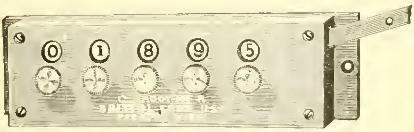
No.	Size Ins.	Ship. Wt. Lbs.	List Price
4	$6\frac{3}{4}x2\frac{1}{2}x1\frac{3}{8}$	$3\frac{1}{2}$	$8.00
5	$8\ x2\frac{1}{2}x1\frac{3}{8}$	$3\frac{3}{4}$	10.00
6	$9\frac{1}{4}x2\frac{1}{2}x1\frac{3}{8}$	$4\frac{1}{2}$	12.00

Finish: Nickel Plated, Black Enameled, or Copper Oxidized.

Bristol Counter with Bar Lock

Specifications for this style are the same as for the regular Bristol.

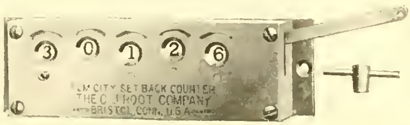
Number of Counter corresponds with number of figures.



"Elm City" Counter

No.	Size Ins.	Ship. Wt. Oz.	List Price
2	$3\frac{1}{4}x1\frac{3}{4}x\frac{5}{8}$	12	$4.50
3	$4\ x1\frac{3}{4}x\frac{5}{8}$	15	6.00
4	$4\frac{3}{4}x1\frac{3}{4}x\frac{5}{8}$	18	8.00
5	$5\frac{1}{2}x1\frac{3}{4}x\frac{5}{8}$	21	10.00
6	$6\frac{1}{4}x1\frac{3}{4}x\frac{5}{8}$	24	12.00

Finish: Polished Brass, Whitened Dials.



"Elm City" Set-Back Counter

No.	Size Ins.	Ship. Wt. Oz.	List Price
4	$4\frac{3}{4}x1\frac{3}{4}x\frac{5}{8}$	18	$8.00
5	$5\frac{1}{2}x1\frac{3}{4}x\frac{5}{8}$	21	10.00
6	$6\frac{1}{4}x1\frac{3}{4}x\frac{5}{8}$	24	12.00

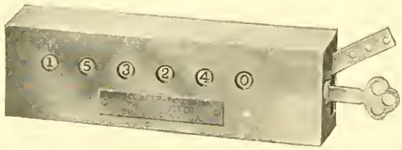
We also make the "ELM CITY" WITH LOCK BAR, the specifications of which are the same as above.

Number of Counter corresponds with number of figures.

No. 96 "Ro-Co" Counter
Operated by Rotating Shaft, No Springs

	No.	Size Ins.	Ship. Wt. Lbs.	List Price
5 Fig.	No. 95	$8\ x2\frac{3}{4}x1\frac{3}{4}$	4	$10.00
6 Fig.	No. 96	$9\frac{1}{2}x2\frac{3}{4}x1\frac{3}{4}$	5	12.00

Black Enamel Finish.



No. 26 "Ro-Co" Counter
Reciprocating Type

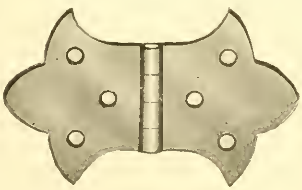
6 Fig. Size $8x2\frac{1}{4}x\frac{3}{4}$ ins. Ship. Wt. 30 oz. List Price, $12.00.
In Nickel Plated or Copper Oxidized Finish.

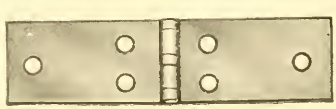
No. 55 "Ro-Co" Counter

4 Fig.	No. 54.	Size $4\frac{3}{4}x1\frac{7}{8}x1\frac{1}{4}$ ins.	List Price $8.00
5 "	" 55.	" $5\frac{1}{2}x1\frac{7}{8}x1\frac{1}{4}$ "	" " 10.00
6 "	" 56.	" $6\frac{1}{4}x1\frac{7}{8}x1\frac{1}{4}$ "	" " 12.00

Made entirely without springs and has a nickel plated closed case.

WE ALSO MAKE A LINEAL COUNTER AND MEASURING MACHINE.
PLEASE WRITE FOR CATALOG M AND DISCOUNT SHEET.

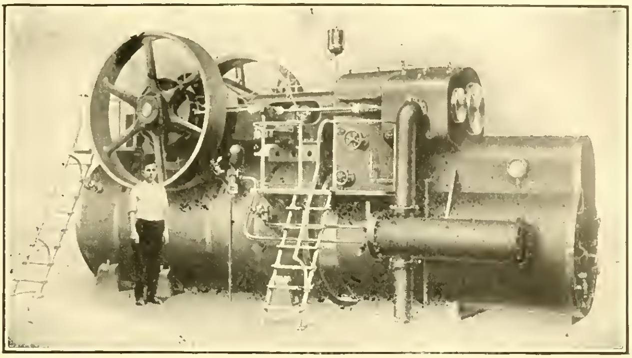




BUCKEYE ENGINE COMPANY

SALEM, OHIO

STEAM ENGINES, GAS ENGINES AND LOCOMOBILES



Buckeyemobile

THE AMERICAN LOCOMOBILE

A self-contained Power Plant of Highest Efficiency.

The Buckeye-mobile is a complete high-grade steam plant in a single compact unit. A compound engine mounted on the boiler produces power on less than 10 lbs. of steam per horse power hour. This economy is obtained through the effectual utilization of high pressure superheated steam and by the elimination of radiation losses which are prevented by enclosing the cylinders, the superheater and all piping, valves and fittings in the smoke hood through which the flue gases circulate before going to the stack. A pump, direct driven from the main engine, feeds the boiler through a feed water heater in the exhaust line.

Buckeye-mobiles normally operate condensing, the air pump being driven by the main engine, but they show excellent economy when running non-condensing and should be so operated when the exhaust steam can be used for heating purposes.

THE SUPERIORITY OF THE BUCKEYE-MOBILE.

ECONOMY OF FUEL—From one to one and half pounds of coal (depending on the quality) produce a horse power hour, or a kilowatt hour is generated on 1¾ to 2½ lbs. of coal.

EASY SUPERVISION—It is easily handled. The small quantity of fuel used reduces the labor of firing to a minimum. Every part is easily accessible.

USES ANY FUEL—The Buckeye-mobile is a universal fuel user. Steam coal of all grades, fuel oil, gas or refuse may be utilized by proper modifications of the furnace.

UNIVERSAL APPLICATION—It is suitable for all situations where a cheap reliable power is desired, such as electric stations, pumping plants, factories, office buildings, irrigation plants and flour mills.

DEPENDABILITY—Reliable operation is insured by its simplicity. There are but few moving parts and the nature of every element, for example, the removable corrugated furnace boiler, plain continuous tubular superheater, single piston valve engine, flanged valves, pipe fittings of steel and valveless vacuum pump, contributes to the very lowest maintenance and depreciation costs.

ECONOMY IN SMALL PLANTS—The usual small steam plant is notoriously wasteful of fuel. The Buckeye-mobile, however, even in the smallest sizes, produces power on less fuel than the largest compound condensing plants of the usual design using saturated steam.

TEST BEFORE SHIPMENT—Each machine is tested in the factory. The purchaser may witness the test and order the unit shipped only when all guarantees have been fully met.

Built in nine sizes from 75 H. P. to 600 H. P.

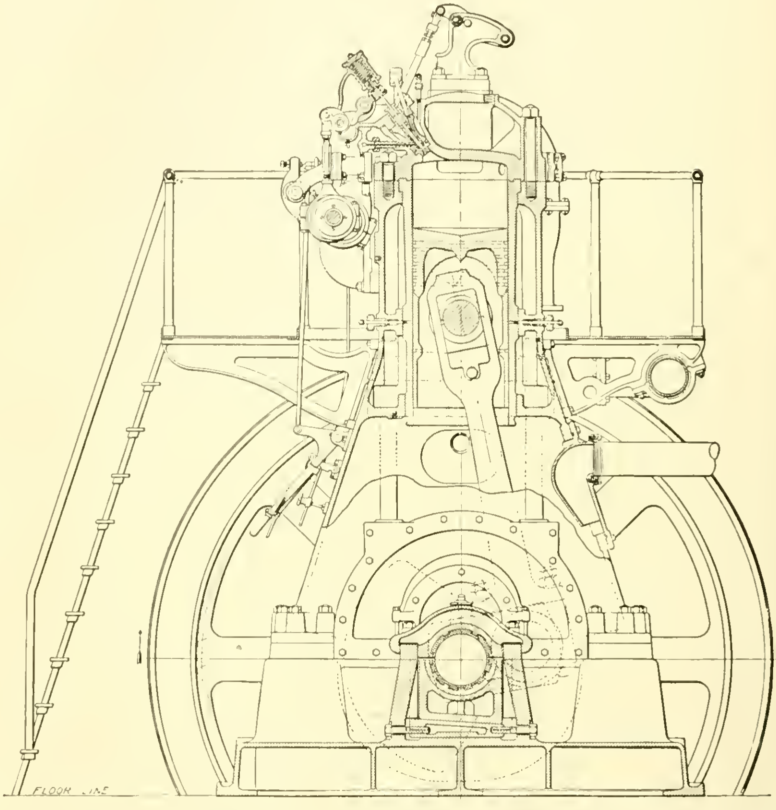
Complete information in Bulletin 10-B sent on request.

LYONS ATLAS COMPANY

INDIANAPOLIS, INDIANA

ATLAS OIL ENGINES—DIESEL TYPE

Vertical, Four-Cycle—300 to 1,000 B. H. P. Units



The well-known Diesel cycle of combustion, as successfully developed in Europe, without modifications of any kind,—housed in a simple, massive structure,—a liberal surplus of carefully selected metals, scientifically distributed,—every part accessible, all bearings conveniently adjustable,—a thoroughly modern design, suitable for continuous service,—as durable and dependable as the best steam plant.

Ignition by compression, no magneto, hot tube, carburetor or mixer.

Gradual combustion without explosions.

Burns cheapest and heaviest fuel oils,—either paraffin base from the Eastern fields, or asphaltum base from California and Mexico.

A self-contained, compact unit, occupying small space, ready to start from a cold standstill and take on full load within one minute at any time. No stand-by losses.

NATIONAL METER COMPANY

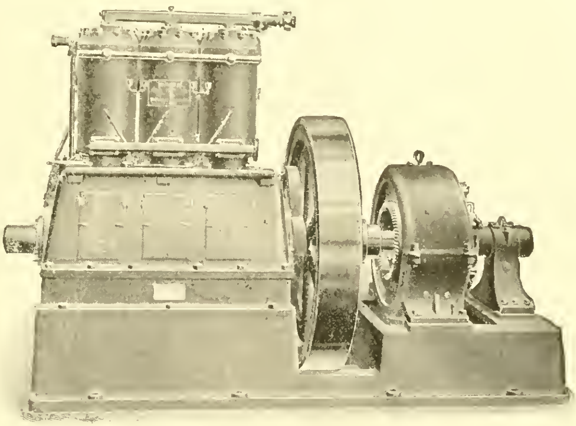
NASH INTERNAL COMBUSTION ENGINES

to operate on

Illuminating Gas, Gasoline or Producer Gas

Simple, Silent, and Efficient

The valve mechanism of the NASH is external to the engine and conveniently placed so as to be under the eye of the attendant. Grouped with it, is the ignition timing device, the mechanically operated oiling system and the starting mechanism.



All sizes of NASH engines are of the four cycle type and are fitted with throttling or hit and miss governors as may be selected or best suited to the conditions.

The National Meter Company is the originator of the throttling governor for gas engines and the NASH was the first gas engine to be equipped with it.

In regulation, the NASH Gas Engine is on a parity with that of the best steam engines.

Due to its high economy, closeness of regulation and quietness of operation it meets a great range of power requirements.

COMPARATIVE COST OF POWER OF VARIOUS TYPES OF ENGINES

Type of Engine	Fuel	Price	Fuel Consumed per B. H. P. per Hour	Cost per H. P. per Hour	Cost 100 H. P. 10 Hrs.
Simple Slide Valve Steam....	Bituminous Coal	$3.50 per ton	8 lbs.	.0124	$12.40
Compound Condensing Corliss	Bituminous Coal	3.00 per ton	3 lbs.	.0045	4.50
Steam Turbine..............	Bituminous Coal	3.00 per ton	3 lbs.	.0045	4.50
Oil Engine	Fuel Oil	.036c. per gal.	1/12 gal.	.003	3.00
Nash Gas Engine	Natural Gas	25c. per M.	10 cu. ft.	.0025	2.50
Nash Gas Engine on Producer Gas..............	Coke	5.00 per ton	1¼ lb.	.0031	3.10
Nash Gas Engine on Producer Gas	Lignite	1.75 per ton	2 lbs.	.00175	1.75
Nash Gas Engine on Producer Gas................	Anthracite Buck	4.00 per ton	1 lb.	.002	2.00
Nash Gas Engine..........	Illuminating Gas	75c. per M.	18 cu. ft.	.0135	13.50
Nash Gasoline Engine.......	Gasoline	16c. per gal.	1/10 gal.	.016	16.00
Electric Power.............	....	3c. per KW hr.	....	.0225	22.50

BEST MANUFACTURING CO.

VALVES

The line of "Best" Valves is summarized as follows:

IRON BODY: **Low Pressure** for Vacuum and 25 pounds steam.

Back Pressure; Automatic Exhaust Relief; Combination Exhaust Relief and Back Pressure; Parallel Seat, Split Wedge Gates and Transfer Valves.

Standard for 125 pounds steam.

Parallel Seat, Split Wedge Gate Valves; Globe, Angle and Cross Valves.

Miscellaneous

Gulland Automatic Cushioning Water and Float, Gate with Clean-Out Pocket, and Snort Valves.

SEMI-STEEL: **Medium** for 175 pounds steam.

Globe, Angle and Cross Valves; "Best" Adjustable Wedge Gate Valves.

Extra Heavy for 250 pounds steam.

Globe Valves; "Best" Double Adjustable Ball Wedge Gates.

We recommend Gate Valves having one piece stems and no pin in the disc holder.

Extra Heavy Hydraulic for 800 pounds water.

Swing Check, "Best" Adjustable Gate, and Climax Three and Four Way Operating Valves

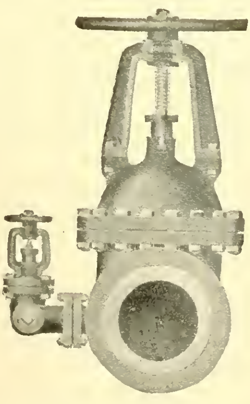
CAST-STEEL: **Extra Heavy** for 250 pounds steam.

Globe and Angle, Swing Check and "Best" Adjustable Wedge Gate Valves.

Special Hydraulic for 1500 pounds water.

Swing Check and "Best" Adjustable Wedge Gate Valves.

"BEST" GATE VALVES



Extra-Heavy and Hydraulic

Cast-Steel "Superheat"

These valves are built on strong construction lines and will withstand heavy duty and abusive service.

The Low Pressure and Standard Valves have a split disc and parallel seats; others have our Patented "Best" Split Adjustable Ball Wedge which adjusts itself to even the slightest change in the angle of the valve seats due to the distortion of the valve body by expansion strains, etc.

"Best" Steel Valves for high temperatures have Monel metal trimmings and one-piece, pinless, Monel metal stems and are unexcelled for use in superheated steam lines.

All metals entering into the construction of our valves are poured in our own factories, insuring uniformity of product. Valves are finished in special machines by skilled mechanics and parts are interchangeable; hydraulic tests determine their serviceability before they are shipped as "Best" Valves.

"Best Model Piping Specifications," a text book on piping, and our complete catalogue No. 103 sent upon request.

BOYLSTON STEAM SPECIALTY CO.

CHICAGO, ILL.

MANUFACTURERS OF STEAM SPECIALTIES: STEAM TRAPS; REGULATING VALVES, BACK PRESSURE VALVES, TANK VALVES; TEMPERATURE CONTROLLERS; STRAINER DEVICES, ETC.

THE BOYLSTON STEAM TRAP

Showing Simplicity of Accessibility

Our 29 years of experience in the STEAM TRAP business have been focalized in the design of a line of STEAM TRAPS, THE BOYLSTON, which are as nearly perfect as mechanical skill and an understanding of requirements can make them.

The modern demand calls for a TRAP of CAPACITY, DURABILITY and POSITIVENESS in operation, and one which allows EASY ACCESSIBILITY to its WEARING PARTS, which points are embodied in the BOYLSTON "Get-at-able" Quick Repairable Improved STEAM TRAP. Other meritorious features are the LONGEVITY of the SEAT and DISC, coupled with the EASE and CHEAPNESS of renewals, without breaking a single pipe-connection—removing the cover, or breaking a GASKET.

In the design of the BOYLSTON STEAM TRAP, we have eliminated the objectionable features, such as COLLAPSIBLE FLOATS, COUNTERBALANCE WEIGHTS, multiplicity of LEVERS, superfluous JOINTS, etc., all of which serve no real or valuable purpose other than to complicate the device. The open-bucket non-collapsible FLOAT is used with a resulting LARGER CAPACITY of the BOYLSTON TRAP.

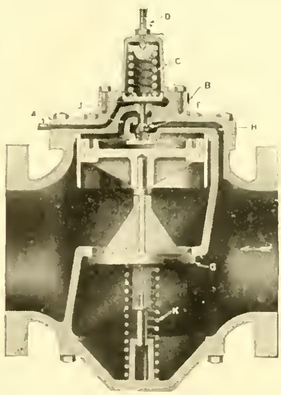
ALL CASTINGS AND PARTS used in BOYLSTON STEAM TRAPS are interchangeable, ACCURATELY MACHINED by SPECIAL TOOLS and TEMPLATES made for that purpose.

The MATERIAL WE USE for the SEAT and VALVE DISC (the only wearing parts) in the BOYLSTON STEAM TRAP is made from BOYLANEY METAL—the hardest known non-corrosive metal in existence.

All other castings are of CHARCOAL GUN IRON.

Boylston Traps Are Made in the Following Classes:

Style A, for pressure ranging from 1 to 30 lbs.
Style B, for pressure ranging from 30 to 125 lbs.
Style C, Extra Heavy, for pressure ranging from 125 to 250 lbs. per sq. in.
Style D, with Unlimited Valve, suitable for pressure from 1 to 125 lbs.
Style E, Extra Heavy Pattern, with Unlimited Valve suitable for pressure from 125 to 250 lbs.



BOYLSTON HIGH PRESSURE PILOT REDUCING VALVE

This valve belongs in a class by itself, and is an entirely different device from the regular common commercial reducing valve.

It is so sensitive and reliable that delivery pressure can be adjusted from as low as 5 pounds to within nearly the initial pressure, and when adjusted the delivery pressure will remain constant regardless of variations in the initial pressure or volume of discharge.

Even with a wide range of operation, no part is of delicate construction nor can the parts be easily deranged.

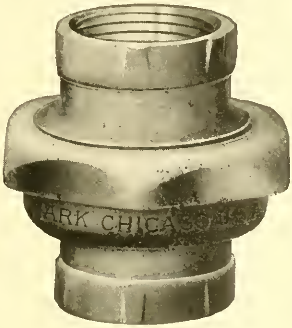
Can be made of steel and nickel suitable for superheated steam at additional cost.

Our New General Catalog No. 10 fully describes Boylston Steam Specialties.

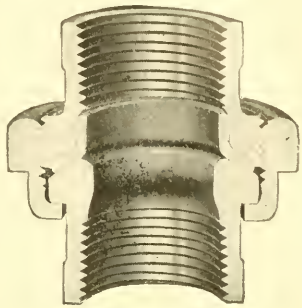
THE MARK MANUFACTURING CO.

EVANSTON, ILL.　　ZANESVILLE, OHIO

MAKERS OF WROUGHT PIPE AND COUPLINGS, BOILER TUBES, ELECTRIC WIRE CONDUIT, WELL CASING, WELL POINTS, PUMP AND WELL CYLINDERS, WELL STRAINERS, WELL VALVES AND TOOLS, PIPE CUTTERS, VISES, THREADING DIES AND PUMP AND WELL SUPPLIES.



Patents Pending



Patents Pending

THE MARK COLD DRAWN STEEL PIPE UNION

Leakless — Rustless — Different

Sherardized after threading to prevent Rusting, Corroding, Freezing.

This new type of pipe union consists of male and female ends, and coupling nut, all Cold Drawn from rolled steel.

It will not leak, break or corrode—BECAUSE:

1. It will expand and contract in *exactly the same degree* as steel pipe with which it is used, consequently it is not subject to leakage at threads, which is unavoidable where malleable and brass unions are used with steel pipe.

2. It is entirely free from blow holes, and sand holes, defects common to all types of unions made of malleable iron and cast brass.

3. It has a "densified" steel seat cushioned against a soft brass seat ring.

4. The threads are accurately cut, and have the same taper as the pipe.

5. It is designed to carry high pressure as well as low, and all sizes are equally strong.

6. All surfaces are Sherardized, and therefore, non-corrosive.

SIZES AND LIST PRICES

Pipe Size...	½	¾	1	1¼	1½	2	2½	3
Steel.......	.50	.70	.95	1.30	1.80	2.50	4.00	6.00
Brass......	2.00	3.00	4.00	5.00	7.00	10.00	12.00	15.00

A. ALLAN & SON

494 Greenwich Street

NEW YORK

INVENTORS AND SOLE MANUFACTURERS OF
ALLAN RED METAL AND ALLAN BRONZE

ALLAN BRONZE

A lead-copper-tin bearing alloy with high lead and high tin content. A close grained homogeneous bearing bronze, that will give a long period of service with small loss of metal by wear; that will minimize friction and that will not have a tendency to heat rapidly, causing the bearing to hug and tear the shaft. A bearing bronze for heavy duty service.

ALLAN RED METAL

A lead-copper babbitt, that will give efficiency at temperatures that would at once destroy any white babbitt metal. A bearing alloy adapted for turbine shaft packings, piston rod and valve steam packings, turbine, motor, crank pin and cross head bearings, and for facing high pressure pistons where superheated steam is used at temperatures up to 150 pounds pressure and 200° superheat.

PISTON ROD AND VALVE STEAM PACKINGS

Allan Red Metal ring castings for piston rod and valve steam packings, will overcome your packing troubles where superheated steam is used. (We do not manufacture stuffing box packings, we supply ring castings for same.)

VALVE DISCS

Allan Metal Globe Valve Discs are metallic and will outlast many vulcanized rubber discs. Excellently adapted for superheated steam service.

BEARINGS AND BUSHINGS

Allan Red Metal will not under the most severe service conditions or neglect in oiling run out of a bearing. It cannot hug, stick to, cut or scar the pin or shaft. In service the bearing takes on a highly burnished copper surface which reduces the friction and wear to a minimum. These are a few of its distinctive features which makes it the babbitt metal that can be depended upon at a critical time. Allan Red Metal cannot be melted in a ladle like white babbitt metal, but must be run down in a graphite crucible like brass. We babbitt bearings at our works for customers who have not got the facilities of a foundry.

We carry in stock bushing patterns for all I. D. and O. D. in lengths 6″, 12″ and 18″, and supply bushings of Allan Red Metal and Allan Bearing Bronze at short notice.

MADISON-KIPP LUBRICATOR CO.

MADISON, WIS.

MANUFACTURERS OF VALVELESS FORCE AND SIGHT FEED MECHANICAL LUBRICATORS.

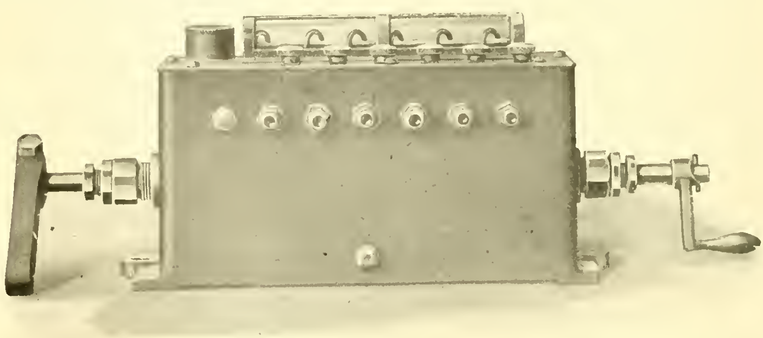
THE ORIGINAL VALVELESS LUBRICATOR

Our Guarantee.

We guarantee our Oil Pumps when properly attached to lubricate satisfactorily any engine of any size, of any make, irrespective of pressure, speed of engine, condition of oil, or skill of operator.

MODEL 30 OIL PUMP.

Our **Model 30 Oil Pump** is especially recommended for internal combustion engines. They are constructed on the **Kipp Valveless** principle, using no checks, springs or valves and will pump any kind of oil at any temperature.



Model 30—6 Feed

We have thousands of these **Oil Pumps** working in the most critical and exacting service.

STANDARD SIZES

No. of Feeds	Symbol	Oil Capacity
2	300-B	4 Pt.
3	300-C	4½ Pt.
4	300-D	5 Pt.
5	300-E	5½ Pt.
6	300-F	6⅓ Pt.
7	300-G	7 Pt.
8	300-H	7¾ Pt.
9	300-I	8½ Pt.
10	300-J	9¼ Pt.
11	300-K	10 Pt.
12	300-L	10¾ Pt.

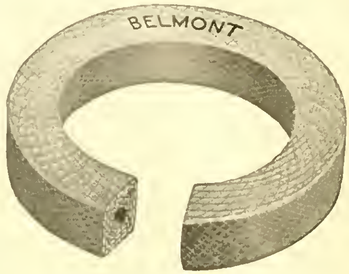
Write for our Catalogue descriptive of Model 30 Oil Pump.

CLEMENT RESTEIN COMPANY, INC.

PHILADELPHIA, PA., U. S. A.

BELMONT PACKING FOR STEAM, WATER, AMMONIA, HYDRAULICS, OIL, GASES, ACIDS, ETC.

BELMONT HOLLOW CENTER PACKING.



Belmont Hollow Center Packing. Style No. 19

Belmont Hollow Center Packing, Style No. 19, a ring of which is here shown, has several important advantages over all solid packings of either the square, round or wedge construction. In removing the old style "rubber core" and making this material with a hollow center the manufacturers have achieved remarkable results First, *having a hollow center*, it weighs much less than the solid packings, and price per pound being the same, the cost for packing a given rod or plunger is much less. More important than this, however, is the fact that the hole provides a place for all excessive expansion or swelling, with the result that there positively can be no more friction on the rod or plunger than is necessary to withstand the initial pressure. Nor can it become tight enough on the rod or plunger at any time either from undue gland pressure or swelling to run hot and "burn."

It is recommended for **steam, ammonia and oils,** for **elevator plungers, hot and cold water pumps** and all conditions of hydraulic service where a stuffing-box packing is required. It is particularly efficient on **outside packed boiler-feed pumps for hot water** where much trouble is experienced with solid packings on account of excessive swellings. Try it. Your initial trial order will be filled with a positive guarantee to give you satisfaction or no pay. May we have a trial order under these conditions? Booklet illustrating and fully describing Belmont Hollow Center Packing for the asking.

BELMONT BRAIDED SUPERHEAT STEAM PACKING.

Belmont Braided Superheat Steam Packing. Style No. 751

Particular attention is invited to our **Belmont Braided Superheat Steam Packing, Style No. 751.** Unexcelled for all conditions of Superheated Steam and particularly recommended for **Gas and Marine Engines, Air Compressors, Hot Air Blasts** and every other service requiring a packing **for extreme high temperature and high speed.**

In process of manufacture each strand of asbestos cord is thoroughly impregnated with finely prepared lubricating graphite in conjunction with our special heat-resisting compound. The required number of strands for the various sizes of packing are braided into a solid piece and when placed in the stuffing-box will not blow out for the reason that **as the packing is worn away by the rod each separate strand takes its wear endwise to the rod.** It positively will not harden in service, and for this reason extra rings may be added from time to time as required without removing the rings in service.

BELMONT COMBINATION STEAM PACKING, STYLE No. 756.

A combination of **Belmont Styles No. 19 Hollow Center Packing and No. 751 Superheat Steam Packing** for steam pressures up to 150 pounds.

The Hollow Center Packing used in combination with our Superheat Steam Packing makes it subject to control at all times and lubricates the wearing parts.

Made for packing space $\frac{3}{8}$ inch or larger.

THE B. F. GOODRICH COMPANY

AKRON, OHIO

Offices in all principal cities

MANUFACTURERS OF MECHANICAL RUBBER GOODS, TIRES, ETC.

HOSE

WATER HOSE covers a wide range of usage, making it quite out of the question to advance any specific recommendations as to quality.

"WHITE ANCHOR" and "AKRON"—special grades for unusual conditions of service.

"TRITON," "CASCADE," "DELUGE,"—regular grades for all general purposes. Braided fabric water hose—in either smooth or corrugated cover.

STEAM HOSE must be heavily constructed to stand the pressure, and the inner lining must be so compounded as to resist the action of steam under varying temperatures.

"GOODRICH"—for high pressure. This is truly a long-life hose.

Special coverings for steam hose: Red Painted woven cotton cover, Woven Marlin Cover, Asbestos Wire-Wrapped cover.

PNEUMATIC HOSE wrapped duck—50′ length style:

"GOODRICH"—the highest quality for the hardest service.

"AKRON"—the standard hose, for all general purposes.

Wire wrapped pneumatic tool hose.

BRAIDED-FABRIC PNEUMATIC HOSE—smooth or corrugated.

AIR DRILL HOSE is heavily constructed throughout with a layer of canvas on the outside as a protection against cuts and abrasions.

"GOODRICH"—exceptionally high quality, unequalled for wear.

"QUARRY"—our standard grade and biggest seller.

BOILER WASHOUT HOSE is made in extra heavy weight to withstand the rough service it encounters. We advocate our heavy "Boiler Washout Hose" for turbine tube cleaner work. Made in two grades, "Goodrich" and "Akron."

SUCTION HOSE is made in a variety of grades to suit any purpose, either smooth or rough bore style.

DREDGING SLEEVES, OIL SUCTION HOSE, OIL WELL DRILLERS' HOSE, OIL CONDUCTING HOSE, GASOLINE HOSE, SAND BLAST HOSE, COKE HOSE, MARINE DECK HOSE, all especially adapted to the purposes for which they are made.

PACKING

RED SHEET PACKING—an excellent product, in two grades.

RED SHEET BRASS WIRE INSERTED in the same grades.

DIAPHRAGM AND CLOTH INSERTION: Packing highly recommended for their proper uses.

SUPER HEAT PACKING, a combination of rubber and asbestos, especially adapted for high pressures.

RED TUBULAR GASKET PACKING, SPIRAL SQUARE DUCK PACKING, ROUND AND SQUARE DUCK PACKING, SQUARE RUBBER BACK, ROUND PISTON PACKING, AND PURE GUM STRIPS all made to supply the demand for these various kinds.

RUBBER GASKETS

All grades and shapes. No matter what your requirements may be, we can supply them.

RUBBER PUMP VALVES

There is no class of our product which we take greater pride in stamping with the GOODRICH trade mark. Our list of grades is complete; we are always glad to give special attention to unusual conditions.

Made in grey or red rubber.

AMERICAN VULCANIZED FIBRE CO.

Established 1873

P. O. Box No. 920 WILMINGTON, DEL.

MANUFACTURERS OF ORIGINAL VULCANIZED FIBRE

THE IDEAL MATERIAL IS VULCANIZED FIBRE

Characteristics: About the consistency of horn; Good Insulator; Great Mechanical Strength; Tough, Tenacious, Pliable, Durable; Improves with Age; Capable of being Sawed, Turned, Bent, Embossed, Drilled, Threaded, Cut, Sheared, Punched, etc., etc.

STRENGTH in lbs. per sq. inch: TENSILE 9,000–14,000; COMPRESSIVE 38,000–42,000; SHEARING 9,000–13,000; SPECIFIC GRAVITY 1.36–1.46; ELECTRICAL RUPTURE 200–400 volts per 1/1000 inch of thickness.

COMPARATIVE TABLE	Wt. per cu. ft.	Effect of Oil, etc.	Effect Rodents, Vermin, etc.	Brittle or Tough	Effect of Age
VULCANIZED FIBRE.	85	None	None	Tough	Improves
Porcelain, etc.	144	None	None	Brittle	......
Hard Rubber..........	150	Rots	......	Brittle	Deteriorates
Rawhide, Leather, etc....	...	Rots	Destroys	Tough	Deteriorates

STOCK SHAPES—SHEETS, RODS, TUBES
TO ORDER—THE FOLLOWING:

Adjusters (Cord)
Bars (Switch)
Baskets (Hop)
Baskets (Mill)
Baskets (Waste) "Vul-Cot"
Bases (Switch)
Bearings (Plain, Thrust, etc.)
Bobbins (Coil)
Boxes
Bumpers (Textile)
Bushings
Cans (Roving)
Checks (Factory Time)
Cleats
Conduits (Interior)
Discs (all kinds)
Ferrules (Condenser, Handle)
Frames (Bolster Case)
Frictions
Gaskets (Oilproof)
Gears (Noiseless)
Gear Blanks
Gibs (Engine, Crossheads)
Handles
Heads (Magnet, Bobbin, Spool)
Insulation
Insulators (Rail Joint)
Linings (Clutch) "Auto"
Mirror Backs
Packings
Pinions
Rings
Rods
Rollers
Rolls (Pinking)
Seats (Chair)
Shims (Switch)
Shoe Horns
Shoes (Brake)
Staples (Insulating Saddle)
Straps (Brake)
Switch Bars
Tacks (Insulated Wiring)
Tags
Telephone Cleats
Tie Plates
Trucks (Mill)
Trunks
Tubes
Valves (Pumps)
Washers (Friction, Thrust, Insulating, Compression, Cock, Pipe Union, Carriage Axle, Car Box)
Wedges (Armature)
Wheels
Wiring Cleats

Our Vulcanized Fibre Rail Joint insulations and steel tie shims prevent failure of block signals as well as serving to cushion and prevent looseness of rails.

Vulcanized Fibre Pinions and Gears frequently give longer and more satisfactory service than bronze or steel. They are noiseless and vermin and oilproof, too.

Send us your problems for solution. Let us devise cheaper, lighter and better parts than those you now use. Our Development Department, composed of Mechanical, Electrical, Physical and Chemical Engineers, is ready to help you.

Quotations and Suggestions gladly furnished.

ENORMOUS STOCKS OF SEASONED MATERIAL INSURE QUALITY AND PROMOTE PROMPT DELIVERY.

ALPHABETICAL INDEX TO

CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

THE JOURNAL
of
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

OCTOBER 1913

35 CENTS A COPY $3 A YEAR

ANNUAL MEETING: DECEMBER 2-5
MONTHLY MEETINGS: NEW YORK, OCTOBER 14; CINCINNATI, OHIO, OCTOBER 16; WORCESTER, MASS., OCTOBER 17

THE ADVENT OF A NEW YEAR

A new fiscal year of the Society begins October 1 and the Committee on Increase of Membership stands upon its threshold with just satisfaction over the results accomplished in the past year. As The Journal goes to press 1016 applications have been filed since October 1, 1912.

In no case has an invitation to join the Society been extended by the Committee to anyone not suggested by a member of the Society. Therefore the success of the work and the standing of the engineers invited has been dependent upon the response made by the membership. Not more than one-tenth of the members have thus far responded to the efforts of the Committee in this important work, and while much has been accomplished a great deal remains to be done, and it is earnestly hoped that the results already obtained will induce every member to shoulder his share of a work in which all can and should participate.

If each member will respond to this appeal during the ensuing year by obtaining the application of *at least one well-qualified engineer*, the added value of membership accruing to each individual will well repay the effort expended in this work.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

H. V. O. Coes	R. M. Dixon	E. B. Katte
F. H. Colvin	W. R. Dunn	R. B. Sheridan
J. V. V. Colwell	J. P. Ilsley	H. Struckmann

Chairmen of Sub-Committees

Boston, A. L. Williston	*New York*, J. A. Kinkead
Buffalo, W. H. Carrier	*Philadelphia*, T. C. McBride
Chicago, Fay Woodmansee	*St. Louis*, John Hunter
Cincinnati, J. T. Faig	*St. Paul*, Max Toltz
Cleveland, R. B. Sheridan	*San Francisco*, Thos. Morrin
Michigan, H. W. Alden	*Seattle*, R. M. Dyer

Troy, A. E. Cluett

OCTOBER 1913 VOL. 35 No. 10

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

CONTENTS

The Journal is published monthly by The American Society of Mechanical Engineers.
Price, 25 cents a copy, or $2 a year, to members and affiliates of the Society; 35 cents a copy or $3 a year to all others. Postage to Canada, 50 cents additional; to foreign countries, $1 additional.
Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

COMING MEETINGS OF THE SOCIETY.

October 14, *New York City*, Engineering Societies Building. Paper: Stability in Aeronautics, A. A. Merrill.

October 16, *Cincinnati, Ohio*. Paper: Stresses in Machine Frames, A. Lewis Jenkins.

October 17, *Worcester, Mass.*, Worcester Polytechnic Institute. Papers: Experiments with Aeroplane Propellers, David L. Gallup; Modern Abrasives, Their Manufacture and Use, Aldus C. Higgins, George Jeppson, Charles H. Norton. For further details, see page 5.

November 19, *New Haven*, Mason Laboratory, Sheffield Scientific School. Subjects: Industrial Coöperative Research, and miscellaneous papers.

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 OCTOBER, 1913 NUMBER 10

ANNUAL MEETING

The Committee on Meetings have arranged a tentative program for the Annual Meeting which is published herewith. The titles of papers are given so far as possible at this early date, and in several cases where papers are still in preparation, the subjects decided upon by the committees in charge of the sessions are announced. A feature of the meeting will be the presentation of the Grasshof Medal, which was placed in the hands of the Society to deliver to its Past-President, George Westinghouse, at the notable Leipzig meeting. Another event of interest which it is expected will be largely attended is the German Dinner scheduled for Thursday evening of the meeting, at which one of the menus of the German trip will be reproduced and addresses will be given with lantern slides upon incidents of the trip.

TENTATIVE PROGRAM

Tuesday Evening, December 2

PRESIDENT'S RECEPTION.

Wednesday Morning, December 3

BUSINESS MEETING, followed by professional session with the following papers:

EFFICIENCY OF ROPE DRIVING AS A MEANS OF POWER TRANSMISSION, E. H. Ahara

COMPARATIVE TESTS OF LINESHAFT BEARINGS, Carl C. Thomas, E. R. Maurer and L. E. Kelso

The Art of Enameling, or the Coating of Steel and Iron with Glass, Raymond F. Nailler

Stability in Flying Machines, Albert A. Merrill (contributed by the New York Local Committee)

Wednesday Afternoon

Railroad Session, with papers on Steel Freight Cars (contributed by the Sub-Committee on Railroads)

Wednesday Evening

Presentation by the Verein deutscher Ingenieure of the Grasshof Medal, to George Westinghouse, Past-President and Honorary Member, Am.Soc.M.E.

Arrangements are being made for a lecture to follow the ceremony of presentation, announcement of which will be made later.

Thursday Morning, December 4

Professional Session, with the following papers:

Pitot Tubes for Gas Measurement, W. C. Rowse

Tests of Vacuum Cleaning Systems, J. R. McColl

Tests upon the Transmission of Heat in Vacuum Evaporators, E. W. Kerr

A New Centrifugal Pump with Helicoidal Impeller, C. V. Kerr (contributed by the New York Local Committee)

A New Process of Cleaning Producer Gas, H. F. Smith (contributed by the Gas Power Section)

Arrangements are also being made for simultaneous sessions on Machine Shop Practice, Cement Manufacture, and Textiles, by the sub-committees in charge of these subjects.

At the Machine Shop Session, among the topics to be discussed are: Use of Gears in Machine Tool Drives, Grouping of Machine Tools, Cast Iron for Machine Tools, Flooded Lubrication and Force Fits.

The discussion at the Cement Session will cover the Use of Powdered Fuel and other subjects to be announced later.

The Textile Session will take up Cost Finding and General Efficiency, Heating Buildings through the Sprinkler System, and Fire Escapes as applied to Textile Mills.

Thursday Afternoon

Excursions to points of interest in New York and vicinity.

Thursday Evening

German Dinner, reproducing one of the menus from the trip abroad. This will not only be a reunion of those who went on the trip, but is being arranged with a view to giving those who were unable to participate some idea of the many interesting events which the American guests enjoyed. Addresses on the German trip will be made, illustrated by lantern slides.

Following the dinner a Dance will probably be arranged for.

Friday Morning, December 5

Session on Fire Protection.

Among the subjects to be discussed are the Management of Valves controlling Automatic Sprinkler Heads, Extinguishing of Fires in Oils and

Volatile Liquids, and the Fire Hazard in Turbo-Generators. Contributed by the Sub-Committee on Fire Protection.

Friday Evening

College Reunions. It has been the custom for the alumni of certain of the technical schools to hold reunions in New York at about this time of the year, and an opportunity will be offered for such gatherings on this evening. The alumni of Stevens Institute of Technology are arranging for a theater party, to which the Society and their guests are invited. Supper and informal dancing at a convenient hotel will follow. The alumni of Sheffield Scientific School will arrange a similar reunion, details of which will be given later.

MEETING IN WORCESTER

The meeting in Worcester, Mass., will be held on October 17, instead of October 10 as originally announced, and will have the following program. Boston members of the Society will leave for Worcester on the noon train from South Station, Boston, due at 1.04 p.m., and will be conveyed to the Worcester Polytechnic Institute by automobile. Luncheon will be served and an opportunity afforded for an inspection of the Institute buildings and equipment. At 2.30 the guests may either attend a lecture by Professor Gallup on Experiments with Aeroplane Propellors, followed by an inspection of aeroplane tests at a point a few miles from Worcester, or may visit any of the following industrial establishments: Grafton & Knight Manufacturing Company, Crompton & Knowles Loom Works, American Steel & Wire Company, Worcester Pressed Steel Company, Worcester Electric Light Company, United States Envelope Company, Heald Machine Company, Reed & Prince Manufacturing Company, or Osgood Bradley Car Company.

The party will reassemble at the Norton Company works at 4 o'clock, and papers upon Modern Abrasives, their Manufacture and Use, by Aldus C. Higgins, George Jeppson and Charles H. Norton, will be delivered. An inspection will then be made of the plant. Dinner will be served at 7 o'clock at the New Bancroft Hotel, at $1.50 per plate. This will be an entirely informal affair and brief talks will be made by Charles G. Washburn and James Logan on topics connected with the Worcester industries. Boston members will return on the 9.42 train due at 10.45, and in case the number who desire to attend is large enough, arrangements will be made for special trains both to and from Worcester. Those who cannot take in the entire program will be welcomed for such time as they can spend.

REPORT OF THE NOMINATING COMMITTEE

The Secretary announces the receipt of the following report from the Nominating Committee, consisting of John R. Freeman, chairman, Chas. T. Main, Thomas Morrin, Fred. Sargent, and C. C. Thomas: For President, James Hartness, Springfield, Vt.; Vice-Presidents (for two years), Henry L. Gantt, New York City, E. E. Keller, Detroit, Mich., H. G. Reist, Schenectady, N. Y.; Managers (for three years), A. M. Greene, Jr., Troy, N. Y., John Hunter, St. Louis, Mo., Elliot H. Whitlock, Cleveland, Ohio; Treasurer, Wm. H. Wiley, New York City.

CURRENT AFFAIRS OF THE SOCIETY

The attention of the membership is called to the increasing number of meetings of the Society held in the several cities of the Union. It is the cordial desire of the Council that these meetings shall be extended wherever the members are willing to organize and carry on these activities, the Society being ready to finance the undertaking under appropriation by the Council upon the request of the local members interested. Further particulars will be furnished by the Secretary. The Council is anxious to have the membership feel that the Society is of direct benefit to each one individually, and an officer of the Society will be pleased to assist in the organization of such meetings or to visit groups already organized at any time.

INTERNATIONAL ENGINEERING CONGRESS 1915

Invitations emanating from the five national engineering societies of America have been issued to the principal societies of the world by the San Francisco general committee, of which Prof. W. F. Durand and William A. Cattell are respectively chairman and secretary. Col. Geo. W. Goethals will be Honorary President of the Congress, and the third week in September 1915 has been chosen as the date. It is hoped that the invitations issued will be generally accepted, and especially that our friends in Europe with whom the members have formed such close relationships will attend in a body and permit the American engineers to return in part the many hospitalities which have been enjoyed abroad.

DR. GOSS'S NEW UNDERTAKING

The President of the Society, Dr. W. F. M. Goss, Dean of the engineering department of the University of Illinois, has been

granted a leave of absence for one year, in order that he may accept the chairmanship of a commission appointed by the City of Chicago to work out a solution of the problem of smoke abatement in that city and of the electrification of the terminal facilities of all the railroads centering in Chicago.

LIBRARY SEARCHES

The value of library service to every member of the Society cannot be too often stated. We have one of the largest technical libraries on the continent, containing besides its many volumes 700 technical periodicals, and having a staff of six librarians available for the particular benefit of members living at a distance from headquarters. Every inquiry receives prompt attention and is free of expense except for extraordinary services, for which members are naturally glad to pay.

Calvin W. Rice, *Secretary.*

CORRECTED DISCUSSION BY SANFORD E. THOMPSON

In the published discussion upon the Boston meeting of last March, which appeared in The Journal for June, the abstract of the remarks made by Mr. Sanford E. Thompson gives an entirely erroneous impression of the views actually expressed. We therefore publish the paragraph properly corrected. The subject under discussion was Concrete Floors and Their Wearing Qualities. Mr. Thompson stated that while concrete floors generally showed wear under trucking they could be built to withstand it successfully. He referred to a test which he had made in order to determine what precautions were necessary to provide good wearing qualities and pointed out the fact that an especially good floor surface would wear glossy and would not dust; while a poor surface would wear down to a dead white color. Sand for surfacing should be coarse.

APPLICATIONS FOR MEMBERSHIP

The Membership Committee have received applications from the following candidates. Any member objecting to the election of any of these candidates should inform the Secretary before November 15, 1913:

Ackland, H. B., New York, N. Y.
Aldworth, Edward H., Montreal, Canada
Allman, John H., Butler, Pa.
Ammen, Francis DuP., New York, N. Y.
Anderson, Pelle, Milwaukee, Wis.
Arnold, John A., Stamford, Conn.
Avram, Mois H., New York, N. Y.
Babcock, Sylvester, Wilkinsburg, Pa.

Bates, Charles J., Jr., Highwood, N. J.
Baumgartner, Chas. G., Chicago, Ill.
Bebb, J. C., San Francisco, Cal.
Becker, Luther. Schuylkill Haven, Pa.
Bendt, Ernest R., Kenosha, Wis.
Benson, Carl H., San Francisco, Cal.
Bethel, Joseph N., Woonsocket, R. I.
Blee, Harry H., Sacramento, Cal.
Blessing, George F., Swarthmore, Pa.
Bonham, H. G., Pulaski, Va.
Borden, Moro M., Collingswood, N. J.
Bott, George R., New York, N. Y.
Breckenridge, Andrew L., Providence, R. I.
Briggs, Lester G., St. Johnsbury, Vt.
Brown, Rezeau B., Milwaukee, Wis.
Browne, Frank Atwood, Wheeling, W. Va.
Bullock, Wm. E., Philadelphia, Pa.
Callan, Wm. H., Franklin, Pa.
Campbell, Robert D., Hoboken, N. J.
Carpenter, Ralph E., Woonsocket, R. I.
Clark, Addison L., La Grange, Ill.
Cocks, Frank L., Brooklyn, N. Y.
Copland, Alex. W., Detroit, Mich.
Cowen, Harry, New York, N. Y.
Coyle, Andrew M., New York, N. Y.
Custer, Levitt L., Dayton, Ohio
Daniel, Thomas L., Robbinsdale, Minn.
Davenport, Wm. S., New Bedford, Mass.
David, Wm. H., Tottenville, N. Y.
Davis, Francis P., Providence, R. I.
Davis, Herman H., Boston, Mass.
Day, Charles H., E. Cleveland, Ohio
Deily, Arthur T., Perkasie, Pa.
Dempwolf, Charles J., Paterson, N. J.
Devens, Richard, New York, N. Y.
Dodgson, John K., Paterson, N. J.
Dombrowsky, Walter F., Newark, N. J.
Donovan, Wm. J., New York, N. Y.
Dorman, Neal W., Toledo, Mich.
Dreffein, Henry A., Chicago, Ill.
Duff, Philip J., New York, N. Y.
Dunn, Edward L., Worcester, Mass.
Eckert, Arthur C., St. Louis, Mo.
Eckfeldt, John J., Latrobe, Pa.
Edwards, J., Detroit, Mich.
Ellenwood, Frank Oakes, Ithaca, N. Y.
Evans, Cadwallader, Jr., Stellarton, N. S.
Farr, Roy S., Tampico Mexico
Farrell, Frederick L., New York, N. Y.
Field, Allan B., Pittsburgh, Pa.
Finlayson, Edward H., Jr., New York, N. Y.
Flanigan, Edwin B., Wilkesbarre, Pa.
Flinn, Melville S., Chicago, Ill.
Flory, John H., Columbus, Ohio
Flowers, H. Fort, New York, N. Y.
Fowden, Wm., Concrete, Colo.
Freeman, W. J., Madison, Wis.
Freshney, Samuel A., Grand Rapids, Mich.
Fuller, Henry J., New York, N. Y.
Gilbert, Harold A., New York, N. Y.
Goddard, Archibald N., Athol, Mass.
Goldthwaite, Harry W., Easton, Pa.
Gottfried, Carl M., Chicago, Ill.
Graburn, Arthur L., Toronto, Canada
Grace, Edward S., New York, N. Y.
Grauten, Sylvester H., Gatun, C. Z.
Gurney, E. R., Springfield, Mass.
Hammer, Edwin W., New York, N. Y.
Hare, Charles R., Hartford, Conn.
Harleman, Samuel T., Bethlehem, Pa.
Harris, Ford W., Los Angeles, Cal.
Hayward, Harold A., New York, N. Y.
Hill, Monroe R., Great Falls, Mont.
Hovey, Otis E., New York, N. Y.
Hunter, E. E., Oklahoma City, Okla.
Johnson, Henry W., Bridgeport, Conn.
Jones, Wm. B., Stamford, Conn.
Keating, D. A., Bridgeport, Conn.
Keep, Henry, New York, N. Y.
Klausmeyer, David C., Cincinnati, Ohio
Klein, George F., Kansas City, Mo.
Klotz, Harry J., Troy, N. Y.
Koch, Henry, Rahway, N. J.
Koepel, Edward, Beacon Hill, Mich.
Krause, Albert C., Sparrows Point, Md.
Lakey, Arthur B., New London, Conn.
Lask, Frederick, New York, N. Y.
Lawatsch, Frank R., Lehigh Gap, Pa.
Lee, Wallace R., Havana, Cuba
Leonard, Chas. S., Albany, N. Y.
Lewis, Fitz James, Empire, C. Z.
Lister, Alfred, Newark, N. J.
Logan, Maurice H., Jersey City, N. J.
Lowell, George C., Gary, Ind.
Luckenbach, Owen F., Oil City, Pa.
Luhn, Clarence W., Cincinnati, Ohio
McConnell, Robert S., Philadelphia, Pa.
McCormick, Edmund B., Washington, D. C.
McIlvrid, James, Jersey City, N. J.
McIntosh, Robert, Calumet, Mich.
McKee, William N., Fitchburg, Mass.
McMillan, Luther B., New Braunfels, Texas
Magie, Wm. E., Evansville, Ind.
Maginnis, Wm. S., Connellsville, Pa.
Mahood, David M., Jr., Brooklyn, N. Y.
Mark, Perry C., Zanesville, Ohio
Mathewson, Frank E., Jersey City, N. J.
Maurer, Daniel A., Fairmont, W. Va.
Mawson, Robert, New York, N. Y.
Messenger, Robert P., Brussels, Belgium
Mickle, Frank A., Columbus, Ohio
Millane, Rupert F., Melbourne, Australia
Miller, C. D. S., Bridgeport, Conn.
Mills, Wallace C., Janesville, Wis.
Moody, Frederick H., Toronto, Canada
Moore, E. A., Springfield, Mass.
Moyer, Wm. J., Brooklyn, N. Y.
Myers, James L., New York, N. Y.
Nichols, Charles K., New York, N. Y.
Noble, Wm. A. E., Los Angeles, Cal.
Nordin, Arvid, Chicago, Ill.
Oakley, Walter W., Kokomo, Ind.
Omdal, Torgeir, New York, N. Y.
Palsgrove, Grant K., Troy, N. Y.

Parker, Roy T., Harvey, Ill.
Perkins, Nathan W., Jr., Newark, N. J.
Peterson, Edward J., Worcester, Mass.
Pettinos, George F., Bethlehem, Pa.
Prior, Wilbur C., Forestville, Conn.
Putnam, J. Russell, Waterbury, Conn.
Quintana, Ernesto P., Havana, Cuba
Rau, Frank B., Westfield, Mass.
Reuter, Francis J. G., Chicago, Ill.
Robinson, Edwin A., Meriden, Conn.
Rogers, Charles M., Meridian, Miss.
Roos, Delmar G., Bridgeport, Conn.
Rosborough, Caldwell R., Moline, Ill.
Ross, Frank E., Oakland, Cal.
Russell, Thomas N., Chicago, Ill.
Sandman, August G., Baltimore, Md.
Schedin, P. H., Philadelphia, Pa.
Schiffl, Charles, Montclair, N. J.
Scholefield, Crighton W., San Francisco, Cal
Schubert, Arno, New Britain, Conn.
Sellew, Welles H., New York, N. Y.
Serbell, Carl V., Portsmouth, Va.
Sheldon, Lucian A., Schenectady, N. Y.
Skinkle, Jay W., Chicago, Ill.
Sluss, Alfred H., Lawrence, Kansas
Smeallie, John M., Brooklyn, N. Y.
Smith, Herbert J., Greenfield, Mass.
Spencer, Ira H., Hartford, Conn.
Stewart, Harry M., Cincinnati, Ohio
Straub, Theodore A., Pittsburgh, Pa.
Sutton, George Z., Philadelphia, Pa.
Swope, Bruce M., Oakmont, Pa.
Szymanski, Casimir E., Sacramento, Cal.
Talbot, Harry J., New London, Conn.
Tenkonohy, Franklin V., West Detroit, Mich.
Thomas, Wm. R., Pittsfield, Mass.
Trotter, Arthur H., Anyox, Canada
Truitt, R. Marshall, Germantown, Pa.
Tyng, Arthur, Ashland, N. H.
van der Werff, J. N., Toronto, Canada
Waddell, Joseph A., Jr., Worcester, Mass.
Wade, Norman S., Salem Depot, N. H.
Wait, J. Russel, Charles, S. C.
Wall, Harold M., Memphis, Tenn.
Walsh, W. J., Chicago, Ill.
Warren, Ralph H., Easton, Pa.
Weber, Peter, Newark, N. J.
Westcott, Arthur L., Columbus, Mo.
White, E. Field, Mansfield, Ohio
Whitehead, Richard H., Miraflores, C. Z.
Whitney, Amos, Hartford, Conn.
Whitney, Wm. F., Ansonia, Conn.
Williams, Frank D., New York, N. Y.
Wotherspoon, Wm. L., New York, N. Y.

PROMOTION FROM ASSOCIATE

Heinen, E. J., St. Paul, Minn.
Johnson, Lester G., Schenectady, N. Y.
Mayhew, Ray, Minneapolis, Minn.
Porter, Will R., Princes Bay, S. I.

PROMOTION FROM JUNIOR

Aull, Jerome J., Cincinnati, Ohio
Bausch, Carl L., Rochester, N. Y.
Bean, Irving McC., Milwaukee, Wis.
Boyer, Frederic Q., New Haven, Conn.
Burgess, A. Bradley, Worcester, Mass.
Dean, Arthur, Flushing, N. Y.
Du Moulin, Walter L., Morenci, Ariz.
Farrington, Thomas H., Owego, N. Y.
Faulkner, David S., New York, N. Y.
Gardner, Henry, New York, N. Y.
Gladfelter, Herbert S., Memphis, Tenn.
Halladay, Harry F., Watertown, N. Y.
Hartwell, Arthur E., Houston, Texas
Lee, Nixon, St. George, S. I.
Norelius, Emil F., Peoria, Ill.
Parsons, Edmund S., Ilion, N. Y.
Pigott, Reginald, J. S., New York, N. Y.
Rowley, Frank B., Minneapolis, Minn.
Ulbricht, Tomlinson C., Havana, Cuba
Verner, Wm. F., Ann Arbor, Mich.

SUMMARY

New applications	186
Promotion from Associate	4
Promotion from Junior	20
	210

THIRD INTERNATIONAL CONGRESS OF REFRIGERATION

In response to the invitation of the American Society of Refrigerating Engineers and of The American Society of Mechanical Engineers, extended at the Vienna Congress of 1910, the Third International Congress of Refrigeration was held in this

country from September 15 to 24. As most of the delegates from foreign countries arrived in New York, The American Society of Mechanical Engineers extended the use of its rooms during the week ending September 14, and arranged a number of events for their entertainment.

The delegates were received in Washington on September 15 at the formal opening session of the Congress, leaving on September 16 for Chicago, where the professional sessions were held. Part of each day was devoted to sightseeing and inspection of points of technical interest. On Sunday, September 21, there was a steamship excursion to Milwaukee, and on Tuesday evening, September 23, a grand banquet, complimentary to the foreign delegates, at which no foods or beverages were served except those preserved by refrigeration under the usual conditions and for the length of time customary in American commercial practice. The Congress was formally closed at the session of September 24, many of the delegates participating, however, in the extended excursions to St. Louis, San Francisco and Panama which had been arranged to follow the meetings.

The engineering activities of the Congress covered phenomena ranging in temperature from the lowest nearly to the highest obtainable with our present means, from within two degrees of the absolute zero to a heat at which iron will melt like butter on a range. From the laboratory of Professor Kamerlingh-Onnes of Leyden were reported experiments made at the temperature of liquid hydrogen and liquid helium, by means of which it was proved that radio-activity is not affected even by the lowest temperature; deviations from Curie's law become sensible at low temperatures, and, for example, oxygen which at higher temperatures in the gaseous state follows the law of Curie, deviates from this law when at low temperatures it has passed into the liquid or the solid state. Metals at very low temperatures lose nearly all of their electric resistance, and become what the investigators call superconductors. It is proposed to utilize this property of the metals for the construction of especially powerful magnets, at first for research purposes. Professor Becquerel reported on his work on the optic and magneto phenomenon and the Hall effect at very low temperatures, this phenomenon giving a clearer insight into the mystery of the structure of matter than could hitherto be obtained. Mr. Gardner T. Voorhees described his experiments with the liquefaction and solidification

of carbon dioxide, and phenomena observed during these processes through special windows in the CO_2 apparatus, which led him to believe that there is an intermediate state of matter on the borderland between gases and liquids. Mr. George Claude gave an illustrated lecture on the liquefaction of air, its properties, and the rare gases obtained as by-products. Liquefaction of air may be used for the production of oxygen, for welding and cutting of metals, for example. It appears, however, that it may also be used for the production of tremendously powerful explosives: carbon immersed in liquid oxygen, and set on fire in open air, burns slowly, but the same material confined in a cartridge and acted on by a fulminate, explodes with the violence of dynamite.

Dr. F. Linde gave an illustrated description of his system of production of hydrogen from water gas by liquefying, by means of liquid nitrogen, the gases in mixture with hydrogen, liquid nitrogen, and when desirable, liquid oxygen also, being obtained as by-products. Tengbeck and Altenkirch described their system of heating and refrigeration by means of resorption refrigerating machines with ice and cold obtained as by-products.

As was to be expected, the problem of transportation of perishable goods in all of its aspects, legal, mechanical, and economic, attracted considerable attention at the Congress. The questions of icing of trains at loading station and in transit, the use of combination heated and refrigerated cars, the transportation of perishable goods from car to steamer by barges in large ports, meat forwarding from distant lands by steamers, fish transportation on special cold storage steamers in such widely scattered places as Central Asia and the Amazon river, all were fully described and discussed. The cold storage of goods was likewise carefully gone into, several papers being devoted to the various questions of cold storage plant administration, relations with the depositors, thickness of insulation to be used, etc.

Attention may be called here to several points powerfully impressed upon the minds of the members, even though they did not form the object of any particular paper. The foremost among them is the remarkably high level on which the technical methods of the refrigerating industry are maintained, especially that branch of it which has to deal with the lowest range of temperature. It is a fact well worth noticing that precisely the

industries which, it appeared only a few years ago, had no commercial chances owing to the prohibitively high cost of manufacture, have since become models of cheap and efficient production. The counter-current principle, utilization of by-products, elimination of heat and cold losses through efficient insulation, and high perfection of design in which every detail is fully thought out, have been in these plants carried out to such an extent that, for example, in the Linde process of manufacture of hydrogen from water gas, the final product, hydrogen, costs somewhat less than the water gas from which it is manufactured, plus depreciation of machinery, the entire cost of manufacture being covered by the cost of by-products recovered, and the day is not far off when the result will be still more favorable. In the Claude process of air liquefaction, the amount of air evaporated to obtain the separation of nitrogen from oxygen is replaced by a nearly similar amount of aid liquefied by that very evaporation, so that after the first batch of liquid air is manufactured, very little additional power is required to carry on the manufacture indefinitely; in the Altenkirch heating system ice is obtained as a by-product, etc. All this shows very clearly what great advantages an industry may derive from having developed along strictly scientific lines, and with a full knowledge at every step of its development of all the losses, technical or economic, incurred in each one of its operations.

In this connection may be mentioned the preponderance of the teaching staff of the technical school in the development of the mechanical side of the refrigerating industry, as illustrated at the Third Congress. The names of Linde, Lorenz, d'Arsonval, Kamerlingh-Onnes, Monteil, were prominent at the Congress both in connection with many technical applications in the industry, and as teachers and discoverers of those laws of thermodynamics to the knowledge of which is due the surprisingly rapid and extensive development of the art of refrigeration in the last few years.

Another important feature of the Congress was the developing of confidence among the people generally in food which has been preserved by refrigeration, and the appreciation of the service which the art of refrigeration renders to mankind by virtue of its ability to conserve all perishable products, making them available out of season, and producing greater uniformity in prices. With the increasing congestion of humanity in the

cities, and the necessity of securing a food supply at great distances from their source, refrigeration cars and ships are now an absolute necessity for the preservation of these perishable products. A comprehensive exposition was held of the latest machinery for the manufacture of various kinds of ice and refrigeration, and of the meats, fish and vegetables themselves which had been kept frozen for periods upward of a year without any change of quality.

The Congress was under the patronage of the President of the United States and of the Secretary of the Department of Agriculture. It was attended by nearly 1000 delegates and may be considered one of the most successful of its kind.

STABILITY IN FLYING MACHINES

By Albert Adams Merrill

ABSTRACT OF PAPER

Any movement of a flying machine can be resolved into a translation of its mass and a rotation about its center of gravity. The translation of the mass of a flying machine has no relation to stability, which is connected only to rotations about its center of gravity.

These rotations can be referred to the three axes of the machine, vertical, longitudinal and lateral. The vertical rudder controls directly, rotations about the vertical axis, and controls indirectly, rotations about the longitudinal axis, since the former rotations alter the relative tip speeds and hence the relative pressures on the tips.

It is a peculiar characteristic of a curved surface that when the angle between the chord of the surface and the surrounding air stream (called the pressure angle) is increased from 0 deg. the center of pressure moves forward. This tends to increase, still more, the pressure angle, which is dangerous. This dangerous movement is offset by the horizontal rudder. A system known as the converging tandem system, which consists of two surfaces equal in area one behind the other and so placed that the pressure angle of the front surface is always greater than the pressure angle of the rear surface, is longitudinally stable because when the pressure angle increases from 0 deg. the center of pressure moves backward. With such a system the horizontal rudder is not needed as an offset.

In most machines lateral stability is maintained by increasing the positive pressure angle of the tip to be raised. This tends to retard that tip and turn the machine in the wrong direction. This false turning movement is offset by the vertical rudder. It is possible to maintain lateral stability by moving a surface to a negative angle on the tip to be lowered, and this will produce a turning movement in the right direction, hence no offset will be needed.

Present machines are so badly designed that dangerous couples are introduced which have to be offset by other couples introduced by the pilot. That we fly as well as we do is not due to the design of the machine but to the skill of the pilot.

It is possible to design a machine in which the couples introduced are righting couples and in which no offsetting couples are needed. Until such a machine is produced there will be only a small market for the sale of flying machines.

STABILITY IN FLYING MACHINES

By Albert Adams Merrill,[1] Wellesley, Mass.

Non-Member

Flying differs from all other methods of transportation because of the fact that the stability of the machine is dependent upon its speed through the air. In this respect the bicycle is the only other machine used by man which resembles the flying machine. As at present designed, the flying machine has no inherent stability, and this is why flying is dangerous. It is the purpose of this paper to analyze the forces involved in flying in order to determine if, by changing the design of machines, it is possible to make flying safer.

2 For the sake of clearness it is necessary to define certain terms as they are used here:

Span is the distance from tip to tip at right angles to the path

Chord is the distance from front to rear of a supporting surface

Angle of Incidence is the angle between the chord and the horizon

Pressure Angle is the angle between the chord and the path of the machine

Vertical Axis is a vertical line through the center of gravity

Longitudinal Axis is a horizontal line through the center of gravity at right angles to the span

Lateral Axis is a horizontal line through the center of gravity parallel to the span

3 Any motion of a flying machine can be resolved into two components: (*a*) a translation of the whole machine; and (*b*) a rotation of the machine about its center of gravity. Since

[1] Special Lecturer on Aeronautics, Mass. Inst. of Tech., 1912–1913.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

the former has no effect upon stability it will not be considered in this paper. Since there are three axes a rotation about the center of gravity can be resolved into three components. I shall consider, first, rotations about the lateral axis, which are of two kinds: stalling and diving. The former occurs when the bow is raised; the latter, when the bow is depressed.

4 These rotations have a great influence upon safety in flight not only because they throw the machine away from a safe horizontal position but, particularly, because they affect the speed of the machine upon which control depends. Of the two, a stalling rotation is the more dangerous for two reasons: (*a*) because the pressure angle is increased, which increases the resistance, and, unless the thrust of the screw is increased proportionally, the speed is decreased. This is always dangerous and many accidents have been due to stalling. (*b*) If the angular velocity of a stalling rotation is high, there will be a rapid increase of pressure per square foot on the supporting surfaces and this sudden strain may cause the machine to collapse. Several deaths have been due to this cause.

5 Two effects may be produced by a diving rotation: (*a*) the speed is always increased, and the path is downward. These of themselves are not dangerous because increased speed means better control and, provided there is sufficient altitude, the machine can be brought back to the horizontal before it strikes the earth. (*b*) If the angular velocity of the diving rotation is too high, a *downward* pressure is produced upon the supporting surfaces which may cause their collapse downward. The explanation of this is as follows:

6 In Fig. 1 AB is the chord of a surface moving to the right. Let AH be the horizon, let $\alpha = BAH =$ the pressue angle and also the angle of incidence, as we are assuming calm air. If the aviator moves the lever so that the angle of incidence is decreased and becomes $\alpha - \triangle \alpha$, the pressure angle also is decreased, hence the lift is decreased and the machine no longer maintains a horizontal course. Assume the new path to be AC and let the angle $CAH = \beta$. When $\alpha = \beta$ the new pressure angle becomes $\alpha - \triangle \alpha + \triangle \alpha = \alpha$ and the pressure is still upward. The danger in a diving rotation depends upon the fact that the maximum value of β per unit time is fixed for a machine of a given weight and speed, so that if, in that time, $\triangle \alpha > \alpha + \beta$, the condition shown in Fig. 2 where AC is the path, is obtained and the pressure is downward.

7 Too rapid a diving rotation has caused the downward collapse of machines and the deaths of some aviators.

8 The rotations described above are caused by the movement of the horizontal rudder and it is evident that the angular velocity of these rotations will determine the magnitude of the danger which follows.

9 I have shown that, by moving the horizontal rudder at the proper speed, it is possible to reduce the angle of incidence without altering the pressure angle. This is safe because with a constant pressure angle there can be no sudden change in the pressure per square foot. I have thus far assumed that there is no wind or that the wind is steady and horizontal. As a matter of fact this condition rarely exists and it is necessary to consider

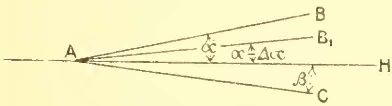


FIG. 1

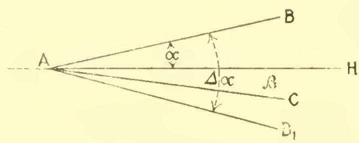


FIG. 2

FIG. 1 DIAGRAM SHOWING HOW THE ANGLE OF INCIDENCE CAN BE REDUCED WITHOUT ALTERING THE PRESSURE ANGLE

FIG. 2 DIAGRAM SHOWING THAT WHEN THE ANGLE OF INCIDENCE IS REDUCED TOO QUICKLY THE PRESSURE ANGLE BECOMES NEGATIVE AND THE AIR STRIKES ON TOP OF THE SURFACE

the problem when flying in a natural wind. Any change in the direction of the natural wind alters the value of the pressure angle and the position of the point of application of the resultant pressure upon a supporting surface is a function of the pressure angle. With any curved surface, such as is always used in flying, when the pressure angle is decreased from 90 deg. to about 15 deg. the center of pressure moves forward, but from 15 deg. to 0 deg. it moves backward. This phenomenon is called the reversal of the center of pressure and it makes the flying machine, as at present designed, inherently unstable. A graphical representation of the movemenut of the center of pressure on a curved surface is shown in Fig. 3. In Figs. 3 and 6, *a* represents upward and *b* downward pressure.

10 At all flying angles (+ 3 deg. to + 10 deg.) the center of pressure moves forward as the pressure angle increases. Let us see what effect this has on stability:

11 In Fig. 4, let AB represent a surface held against a wind AC; then BAC = the pressure angle. Let the point O represent the center of pressure and the center of gravity. Suppose the wind to change to the position AD; then it is evident the pressure angle has been increased by the amount CAD. Let BAC = 5 deg. and CAD = 3 deg., then the new pressure angle will be 8 deg. Fig. 3 shows that when the pressure angle increases from 3 deg. to 8 deg. the center of pressure moves forward. Let the new center of pressure be at

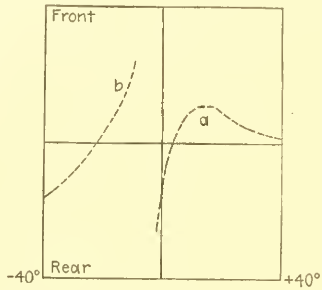


Fig. 3 Diagram of the Movement of the Center of Pressure upon a Curved Surface showing that as the Pressure Angle increases from 0 Deg. to 15 Deg. the Center of Pressure moves forward, which produces an Upsetting Couple

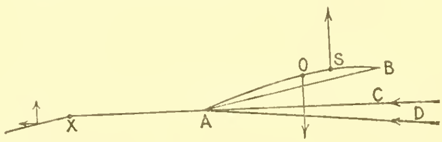


Fig. 4 Diagram showing how the Dangerous Stalling Couple is offset by the Horizontal Rudder

S. This produces a couple tending to cause a stalling rotation, and is just the reverse of what is desired, because, if any rotation takes place about the lateral axis, and some rotation is bound to take place when the wind changes its direction, that rotation should be such as to keep the pressure angle constant, which is generally the important thing in flying. Therefore, it is evident that the couple shown in Fig. 4 is an upsetting couple and that safety requires that it should be offset by some other couple. As a matter of fact this other couple is introduced by the horizontal rudder shown at X, but the point to note is

that this couple must be introduced by the pilot and that the machine, of itself, has no stability. I consider this to be a fundamental error in the design of all flying machines which must be remedied if there is to be any large future for the art.

12 All naval architects know that when a boat tips to the left the center of buoyancy must move to the left in order that the meta-center shall be above the center of gravity. Now, referring to Fig. 4, it will be seen that the change from AC to AD is equivalent to a contra-clockwise rotation about the center of gravity (that is, to the left), letting AC remain stationary, yet the center of pressure moves to the right. The offsetting of this false couple with the horizontal rudder would find its analogy in naval architecture if, when a boat tips to the left, it were neces-

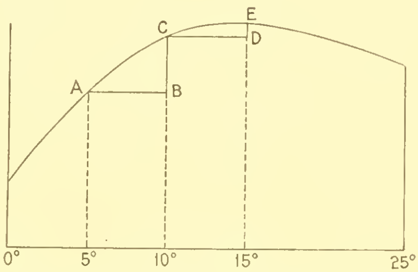


Fig. 5 Diagram of the Lift Graph of a Curved Surface showing that the Value of a Tangent to the Graph decreases as the Pressure Angle increases

sary to use a pontoon on the left side to keep it from turning over. If such a construction were necessary with boats, their use would be very much restricted; yet just such a construction is necessary with the present type of flying machine. That we fly as well as we do is not due to the design of the machine, but to the skill of the pilot.

13 So far as longitudinal stability is concerned, the most superficial study of the subject should teach that a machine must be designed so that when the pressure angle increases, the center of pressure will move backward constantly through all angles from 0 deg. to 90 deg. Let us see if we can solve the problem theoretically:

14 Fig. 5 represents the lift graph of a curved surface and in its fundamental characteristics it is typical of all lift graphs. The

abscissae represent the pressure angles and the ordinates represent the lift. A glance shows the important fact that the value of the tangent to the curve decreases as the angle increases. From 5 deg. to 10 deg. the increased lift is BC, while from 10 deg. to 15 deg. it is only DE. Therefore if one surface is placed behind another in a position such that the pressure angle of the front surface is always greater than that of the rear surface, then, when the angle of the *system* is increased, the center of pressure will move back as it should and we shall have a righting couple. Such a system, known as the converging tandem system, has been tested in the laboratory of M. Eiffel and the graph of the movement of its center of pressure is shown in Fig. 6.

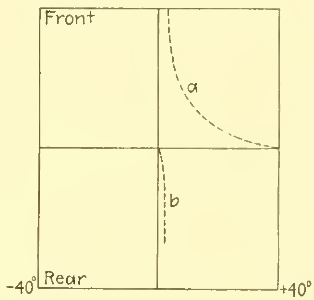


Fig. 6 Diagram of the Movement of the Center of Pressure on a Converging Tandem System, showing that the Couple introduced is a Righting Couple

15 Note that, at small angles, the pressure jumps back to the rear edge, but it is downward so it still produces a righting couple. The method of testing for the center of pressure consists simply in setting the surface with its span vertical on a vertical axis in a current of air, and noting the pressure angle for each particular position of the axis relative to the front edge. With the ordinary curved surface, designed as monoplane or biplane, it is impossible to obtain stability at flying angles, whereas, with the converging tandem, the system can be moved away in either direction and, when free, will return to its original position under the influence of the air. In fact it acts exactly as does a weathervane. I have tested this in speeds up to 120 miles per hour. This system, then, so far as laboratory tests show, has inherent longitudinal stability, and its practical value is sup-

ported to some extent by the fact that all the long flights with models (over 2700 ft.) are made with it. At the time of writing, it has not been given a thorough test with a full sized machine so far as I know. It must not be confused with the tandem system Langley used. In this the pressure angles of the two surfaces were equal, hence it could not have longitudinal stability, as a study of Fig. 5 will prove.

16 Considering the question of the tandem further, with the present type of machine the false movement of the center of pressure necessitates an offsetting couple (produced by the horizontal rudder) and it follows that the machine must be sensitive to the rudder, hence its moment inertia about the lateral axis must not be above a certain limit. This means, however, that, if the machine is sensitive to the rudder, it is also sensitive to gusts. On the other hand, by the very nature of its structure, the tandem will always have a larger moment inertia about the lateral axis than a monoplane or biplane of equal area and weight; hence it will not be as sensitive to its rudder, neither will it be as sensitive to gusts. Criticism has been made of the large moment inertia of the tandem, but I fail to see why this characteristic is a dangerous one, since a righting couple is always introduced when the machine is disturbed. It is evident that the course of a tandem cannot be changed as quickly as that of a monoplane, but that is a point in its favor, not against it. The course of a touring car cannot be changed as quickly as that of a bicycle, yet no one claims that a bicycle is safer than a touring car.

17 There is another point in favor of the tandem. As air leaves the rear of a surface it is moving downward. This constitutes the slip stream of the surface. Somewhere back of the surface the air rises, seeking its normal position. It is possible that a position may be found in the wake where a surface can be placed to great advantage. At the present time, with monoplanes and biplanes, all the energy delivered to the air by the front surface is wasted. It is evident that few naval architects have studied aeronautics else more thought would have been given to using this wake. The tandem offers a chance to utilize this wake.

LATERAL STABILITY

18 Lateral stability has to do with rotations about the longitudinal axis. The resultant pressure on a surface is a function

of two independent variables. The pressure varies as the square of the speed and as less than the first power of the pressure angle. It is evident therefore that a change of speed has more effect on pressure than a change of angle. The relation of the pressure to the speed is constant for all kinds of surfaces, but its relation to the angle depends upon the shape of a cross-section of the surface used.

19 I will consider first the forces involved in producing a rotation about the longitudinal axis when flying in calm air, which is called a banking rotation. Suppose a machine to be flying straight and the vertical rudder is turned. This causes a rotation about the vertical axis and makes the tip speeds unequal. The change of tip speeds produces a change of pressures and causes a banking rotation. The machine banks in the same direction it turns; thus, if the rudder is set for a left turn the right wing moves faster than the left wing, the former rises and the latter falls so that the machine banks to the left. This is as it should be. If we had assumed in the first place that the machine was off its balance laterally, then a turn towards the high side, by retarding the high wing and accelerating the low wing, will bring the machine back to the horizontal position.

20 As in all other phenomena connected with flight the time element is a factor which determines the nature of the result which follows the use of the rudder. In a machine in which the moment inertia about the longitudinal axis is greater than the moment inertia about the vertical axis, too quick a rotation about the vertical axis will spin the machine without giving it time to bank and skidding will result, since without a bank, the direction of the path of a machine cannot be changed. On the other hand, the proper angular velocity of rotation about the vertical axis will produce the proper bank for the turn it is desired to make. The vertical rudder therefore plays an important part in all rotations about the longitudinal axis.

21 However there are other means for producing banking rotations. The one most commonly used was first reduced to practice by the Wright Brothers, and it consists of warping the supporting surface in a manner such that the pressure angles at the tips are unequal, the larger angle being at the tip which must be raised. Practically all machines flying today use this system, either as the Wrights use it or in a modified form. Practically all machines increase the pressure angle of the tip which must be

raised. If the supporting surface is not warped, auxiliary surfaces called ailerons are used to produce substantially the same result. While machines using this system fly, and fly well in the hands of good pilots, there is a fundamental error in this system which increases the danger of flying. Since the pressure varies as the square of the speed it is evident that to change the angle of a tip, which must be raised, in such a way as to reduce its speed will produce a result the opposite of what is desired unless some offset is introduced. When the pressure angle, say of the right tip is increased, the resistance offered by that tip is increased and its speed decreased, hence the machine starts to turn to the right and a banking couple to the right is produced. However this is just the reverse of what is wanted, because in-

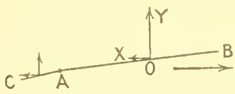


Fig. 7

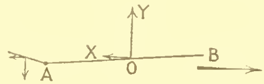


Fig. 8

Fig. 7 Force Diagram of a Surface and an Aileron set at a Positive Angle showing that the *H* and *V* Components produce Opposite Effects

Fig. 8 Force Diagram of a Surface and an Aileron set at a Negative Angle showing that the *H* and *V* Components coöperate to produce Similar Effects

creasing the pressure angle was for the purpose of raising the right tip, while a banking rotation to the right will lower that tip. It is at this point that the rudder comes into play as an offset. The rudder is turned so as to prevent any rotation about the vertical axis and hence keeps the tip speeds equal, then the difference in the pressure angles produces a banking rotation to the left, which is what is wanted. With lateral stability as with longitudinal stability flying machines are designed so badly that a dangerous couple which should not exist has to be offset with another couple controlled by the pilot. The horizontal rudder has to be used to prevent stalling and the vertical rudder has to be used to prevent the disastrous effect of the warp alone. In the Wright machine, but only in the Wright, there is a mechanical connection between rudder and warp which relieves the strain on the pilot somewhat, nevertheless the design is radically wrong because it introduces a force which is not only useless but

which is positively dangerous. It is a very simple matter to design a system in which all the forces introduced can be used and Figs. 7 and 8 will explain how this can be done.

22 In Fig. 7 let AB represent a surface moving in the direction of the arrow and let OY and OX be respectively the V and H components of the pressure upon it. Suppose it is desired to raise this surface and for this purpose an aileron, which hitherto has been out of action, is moved down to the position AC. The component pressures on this are represented by the arrows. It is evident that if the speed is kept constant the surface will rise, but as the H component of the system is increased, the speed will decrease and instead of rising the surface may fall. The problem can be worked out as follows: Compute the horsepower necessary to support the surface alone with a given pressure angle and speed, the weight of the surface being known. This horsepower is to be constant. Move the aileron down to a certain angle and compute the horsepower necessary to support both surface and aileron at the original speed. If the aileron is given a positive angle, which must be done if the surface is to be raised, it will be found that more horsepower is needed; but we have assumed the horsepower to be constant, therefore it is evident the speed of the system must decrease. Since when there is no change in the angle, horsepower varies as the cube of the speed, it is an easy matter to compute the new speed. Knowing the new speed and the pressure angles of the surface and aileron the new lift of the system can be found.

23 These computations are based upon coefficients determined in a laboratory. With Eiffel's coefficients I can show that if the power remains constant and the pressure angle increases, for the first 2 or 3 deg. there is a slight increase of lift, afterwards the lift drops rapidly. This is what I call the fallacy of the positive angle. Within the last six months foreign students are beginning to understand it and as able an expert as Captain Duchene has written upon the subject. He says:

It would seem that in aeroplane construction designers have refused to employ anything but controls acting *differentially;* that is, every time one particular organ of control had to fulfil a definite function it has been so designed, with the greatest ingenuity, as to fulfil precisely the opposite function as well. Sometimes even—and especially with the warp on large-span machines—this opposite effect preponderates and must be overcome by bringing another organ into play. But in any case, the differential

action of the controlling organ compels the designer to make its dimensions unnecessarily large.

Whether with warp or ailerons, the effect aimed at is to raise one wing-tip by increasing its lift, and to lower the other wing-tip by decreasing its lift.

But if we inspect Eiffel's curves for lift or drift we see that for every increase in the angle of incidence, though the lift may increase (which is the effect aimed at by warping), the drift also increases, which is a parasitical effect, for the ensuing drag on the raised wing-tip tends to produce a turning movement in the opposite direction to that which should follow on the inclination of the wing produced by altering the lift on the wing-tips.

The warp therefore acts differentially, so that in large-span machines where the drag is considerable, its detrimental effect has to be counterbalanced by an opposite effect obtained through the use of the rudder.

The necessity for operating the warp in conjunction with the rudder therefore only results from a defect in the method of warping which, as known at present, is a barbarous method.[1]

24 The question now is what can we substitute for the positive angle? From Fig. 7 it is seen that an upward V component and a backward H component must always antagonize each other. As the H component must always be backward suppose a downward V component is used. Instead of pulling an aileron *down* suppose it is pulled *up* on the opposite tip, i.e., on the tip that is to be lowered.

25 Fig. 8 shows what will happen: The V component of the aileron is downward and the increased H component of the system, by retarding the tip, also lowers it. The components work in harmony and no offset is needed. Can anything be simpler or safer?

26 I have shown that the converging tandem should produce inherent longitudinal stability. Any disturbance about the lateral axis will introduce a righting couple which will set up oscillations, which will gradually die out. The magnitude and perodicity of these oscillations will depend upon the strength and direction of the gust, the moments of the pressure on the surfaces about the center of gravity and the moment inertia of the whole machine about the lateral axis. One important feature about these oscillations is their effect upon the lift of the surfaces. As the bow rises the lift will increase, and as the bow falls the lift will decrease. This will result in an undulating flight without however materially alterating the altitude.

27 In calm air it is possible to obtain inherent lateral sta-

[1] **Aeronautics (English), July 1913.**

bility by what is called a dihedral angle. If a line joining the tips of a surface passes above the center of the surface the surface is said to have a dihedral angle. If such a surface is rotated about its longitudinal axis one side of it will become horizontal and the other will move away from the horizontal, hence the difference in the V components on the two sides will cause the surface to move back to its original position through a series of oscillations. But these oscillations differ from those about the lateral axis since at no stage of these oscillations is the lift greater than it was when flying horizontally, while at some stages the lift is very much less, hence such oscillations will cause a great loss of altitude. Of course these oscillations are damped out in time and so a dihedral angle will prevent a machine from turning over, but this does not mean that to depend upon a dihedral angle is safe. Less than 1 per cent of aviation deaths are due to overturning. The largest number of deaths are due to striking the earth at too high a speed with the machine at such an angle that it does not strike *first* on its landing gear. Assuming a loss of manual control in a machine having a dihedral angle there is the highest probability that when the machine finally strikes the ground it will not land on its wheels, and to land in any other way means a smash and possible death to the pilot. Unless they have made a careful study of this subject, few people realize that, for safety in landing, it is necessary not only that the machine should be right side up but that its longitudinal and lateral axis should be within at least 2 or 3 deg. of the horizontal. The dihedral angle alone will never be able to guarantee this condition of safety.

28 Owing to the fact that any system of inherent stability must set up a series of oscillations, and as oscillations about the longitudinal axis always mean a loss of altitude which is a very dangerous thing, it appears to be impossible to obtain a safe system of inherent lateral stability. Certainly, the chances of finding it are less than they are of finding a safe system of inherent longitudinal stability. The converging tandem offers a possible solution of the problem of inherent longitudinal stability because no matter how long the machine oscillates under the combined action of the gust and the righting couple there is no danger of its losing altitude as there always is from oscillations about the longitudinal axis.

29 There is another kind of stability, however, which offers a

chance of making flying safer. This is automatic stability. If a mechanism could be invented which would move the control levers in the proper way and at the proper time, the pilot would be relieved of much strain and flying would be made safer. Since stability is wholly unrelated to translations of the machine and connected only with rotations about one or more axis, it follows that the control mechanism must be sensitive to rotations but not sensitive to translations. This eliminates the pendulum as a possibility. Contrary to belief the pendulum is unsuited for this purpose, because a translation of its point of support sets up oscillations which are not wanted. Mercury cups or other moving fluids are also unsuited for the same reason, i.e., they are sensitive to translations of the machine. The gyroscope is unsuited because it tends to maintain a fixed plane, whereas in practical flying the longitudinal and lateral axis must often take different planes at different times. Moreover, there is one characteristic of the gyroscope which is very bad. It cannot act except it is revolving. It is dangerous to depend for stability upon a mechanism which has to be in motion.

30 This summer at Chicago I examined a mechanism, the details of which I am not at liberty to disclose, which appears to be able to guide a flying machine independently of manual control. It is sensitive to rotations but not to translation, the couple introduced is a static couple, the force employed cannot fail to act and the distributing mechanism is so simple it is hard to see how it can get out of order. To move the levers, power is taken from the engine, the mechanism simply controlling how far and when the levers shall be moved. The system is auxiliary to manual control and can be cut out whenever the pilot so desires.

31 Inherent stability for flying machines is hard to obtain. The problem is different from that of a boat, because a boat is immersed in two fluids of different densities, while a flying machine is immersed in one fluid. There is no reason, however, why stability cannot be greater than it is in existing machines; two fundamental errors in design should be changed now, namely, the use of the horizontal rudder to prevent stalling and the use of the vertical rudder as an offset to the warp. For some years I have been convinced that these offsets are evidences of bad design, and apparently other students are coming around to my opinion.

32 It is 22 years since Langley published his valuable work on plane surfaces, yet, although the Wrights were the first to fly,

no research work worthy of the name has been done in this country and the only scientific progress the world has made had its start in Eiffel's laboratory researches.

33 I hope that this paper will awaken an interest in the theory of aeronautics to the end that engineers will give some of their time and, where able, some of their money, to any proposition which will put aeronautics upon a firm foundation in this country. It is to be regretted that, although aviation had its start here through the work of Langley, Chanute and the Wright Brothers, we are at the present time far behind France so far as real scientific progress is concerned.

34 What is necessary is several well equipped laboratories and able men who can devote all their time to research work. Before aviation is placed upon a firm foundation a correct theory of design must be worked out, and this can be accomplished only by thorough research work in the laboratory.

THE ART OF ENAMELING OR THE COATING OF STEEL AND IRON WITH GLASS

By Raymond F. Nailler

ABSTRACT OF PAPER

The paper opens with a brief history of the art of enameling, going back to the very early stages of its development; the present-day methods of enameling are then outlined. The composition of enamels is treated, showing the chemical actions which take place, the substitution of materials, the theory and practice of what cause the enamel or glass to adhere to steel or cast iron, and the various ingredients used to produce various colors in enamel or glass.

The recent development of enameling larger apparatus and a brief description of this art close the paper.

THE ART OF ENAMELING OR THE COATING OF STEEL AND IRON WITH GLASS

By Raymond F. Nailler, Elyria, Ohio

Member of the Society

Before going into the technology of this art, it will be interesting to note its history in a general way: where it originated and how it was brought down to the present age. The covering of burnt earthenware, porcelain and some metals with a crude enamel took place about the same time as the discovery of glass. Since the time when man first enameled metals, especially gold, silver and copper, he began to be interested in the problems connected with artistic enamels.

2 Colored enamel earthenware has been found in the ruins of Thebes. In the ruins of a great many other ancient cities of Egypt enameled or glass-covered brickwork has also been discovered. That the Egyptians knew how to adorn silver vessels with enamel pictures has been recorded by Pliny the Elder. From Egypt the enameling arts were transferred to Greece and thence to Rome, and some historians maintain that the enameling art came to Italy by Arabia, Spain and the Balearic Islands, and through Roman expeditions the art passed into England, France and Germany. In the museum at Oxford is an enameled ornament which was found in Somerset, the inscription of which dates to the time of Alfred the Great.

3 As a particular example of early art enameling let us briefly consider the so-called enamel painting. Two periods may here be distinguished: The first, known as the "old Limoges style," was characteristic of the time of Francis I (1515-1547). The enamel plate, generally made of copper, was covered with a dark enamel coat. After firing, figures, weaker or stronger accord-

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

ing to the relief desired, were put on with white enamel and the impression of bas-relief thereby brought about. The second period of enamel painting began a generation after the first. This is the so-called period of the "miniature style," which was introduced about the middle of the sixteenth century. It was brought to an extraordinary state of perfection by Jean Petitot (1607-1690).

4 As the demand for the artistic enamels of antiquity and the Middle Ages increased, so the enameling of gold and silver gave way to that of copper vessels, and from this point, if we except the somewhat scattered industry of miniature painting on boxes, such as jewel cases, etc., the absolute decline of the enameling art is to be recorded.

5 In the nineteeth century, which it must be conceded brought one of the most important of Europe's social, educational, and technical revolutions, the enameling business came into great significance and eventually became the enameling industry of today. The commercial introduction of iron and steel made it possible to re-apply the half-forgotten art of enameling iron utensils.

6 In the history of the development of enameling or the modern industrial technology of iron enameling, we are able to speak of two periods with regard to the iron materials employed, viz., of the original enameling of cast iron exclusively and the later application to sheet metal.

7 Before considering the technology of any particular type of enamel it will be well to consider the meaning conveyed by the word enamel. If the present-day enamel be briefly and scientifically designated as a boro-sodium-potassium-aluminum silicate generally colored by metallic oxides, then the following definition given by Popelin deserves to be quoted since this, notwithstanding its length, may be described as most clear and comprehensive: "Enamel is a glass fusible at a low temperature and usually compounded of borates and silicates. This mixture originally colorless combines with the greatest ease with metallic oxides under the influence of a pyrotechnic operation, thereby acquiring various colors according to the nature of the oxide which the enameler can vary at will."

8 The uses to which the general class of ceramic compounds known as enamel is put are varied. We have noted that enamels are used for artistic or decorative purposes. Parallel to this

use we may classify a far more important type of enamels as "commercial," and it is with this type of enamel that we are to concern ourselves. The first class of commercial enamels is that used on cast iron and this classification includes the field of sanitary equipment together with various forms of cast-iron kettles and similar pieces of engineering apparatus. The enameling of sheet steel may be taken as the second class of commercial enamels. The most familiar division of this class includes cooking ware enamels. The various forms of so-called agate and granite ware as well as the single colors are made by enameling sheet-steel forms. The second class of steel enameling which has more recently come into industrial importance is the manufacture of enamel signs, and the third field includes the manufacture of heavy equipment for large scale food preparation, the dairy industries, and general chemical operations. The apparatus in this last case may take the form of tanks, kettles, evaporators, pipes, etc.

9 In outlining the technology of the enameling industries as a whole we may include to a certain extent all of the above commercial classes, certain details of which are varied to meet the conditions of cast iron and various types of sheet-steel products. The outline following, however, is characteristic of all classes.

10 The first step to be considered is the preparation of the enamel. The purity of the raw materials to be used in the compounding of an enamel must be certain and in the cases where materials can vary in strength the actual analysis of the substance must be known to assure proper results. In many cases the secret of an enamel lies in its formula and so the compounding of the batches is very carefully guarded, only a person of responsibility having charge of weighing the ingredients. The various materials are generally kept in bins which are numbered, the person in charge of the mixing having the formula stated in terms of these numbers. The properly weighed batch is thoroughly mixed, this being accomplished either by shoveling carefully on a specially prepared floor or by mechanical mixing by means of a rotating agitator.

11 The product of the mixing room is taken to the smelter in which the various ingredients are fused together in the form of a mass having the characteristics of glass. The furnace in which this operation takes place is a special reverberatory furnace similar to that used in the puddling process in the manu-

facture of wrought iron. The coal is placed on a grate at the front end of the furnace and the burning gases pass over the bridge wall, strike the roof, and are deflected against the batch. The first change which may be noted in the smelter is the driving off of the water from the borax which produces a swelling up of the mixture. The fluxing materials then melt down and as the heating is continued, dissolve the more refractory constituents. If the batch is properly stirred and the temperature of the furnace carefully regulated, the product of this operation is a clear transparent glass containing no particles of unfused material. When a test of the fusion comes up to this standard the furnace is tapped and as the liquid glass flows into a tank of cold water it is broken up by the chilling action of the water, the result being a thorough granulation of the product. The material thus prepared is known as "frit."

12 The next step in the preparation of the enamel involves grinding the frit to a fineness at which it can be applied to the surface of the metal. The mill here used is the ordinary pebble mill lined with porcelain brick and containing very hard flint pebbles. In the cast-iron industry two general processes are used, the dry and the wet, in sheet-steel work only the wet. In the first case the frit is ground dry, the pulverized enamel being sprinkled on the hot cast-iron piece. In the wet process a certain percentage of pure white clay is placed in the mill with the frit and a certain definite amount of distilled water. When certain grades of enamel are to be manufactured various compounds are also added here to aid in producing desired colors, gloss and opacity. An instance of this is the addition of tin oxide in the mill in the production of white cooking utensil enamels. The fineness to which the enamel is ground depends upon the particular use to which it is to be put, manner of application and other factors. In the wet process the essential feature is that it be fine enough to remain suspended in the water assisted by the clay and the so-called "vehicles" mentioned below.

13 At this point we may well take up the consideration of the construction and preparation of the material to which the enamel is to be applied. Cast-iron enamels are applied to castings of the desired shape. In the case of cooking ware enamels the shapes are constructed by pressing and spinning. For heavier equipment such as jacketed kettles the apparatus is con-

structed by riveting or preferably welding the sheet steel in the desired form. The selection of the steel with a view to its chemical analysis is of prime importance. A reliable specification reads as follows:

Sulphur	below	0.040
Phosphorus	below	0.030
Manganese	about	0.40
Silicon	about	0.010
Carbon	about	0.10

The steel must necessarily be free from laminations or other mechanical imperfections.

14 With reference to the construction of heavy apparatus the sheet ranges from $\frac{3}{16}$ in. to $\frac{3}{8}$ in. in thickness. Two general methods of construction are in use: The first involves the formation of unit sections fitted with flanges. These sections are enameled separately, bolted together at the flanges and the desired apparatus so constructed. The preferable practice, however, is to construct the apparatus in one piece by means of autogenous welding, thus avoiding the use of gaskets or other packing materials in erection. That the enamel may properly adhere to the surface of the metal, the latter must be free from dirt or scale and in the case of welded joints the welds must have a preliminary grinding to reduce the roughness. The entire surface of the apparatus is then cleaned by pickling or sand blasting, the latter process being altogether used in cleaning large apparatus. As the crude ware leaves the sand blast it has a roughened, clean, metallic surface and is in the proper condition to receive the enamel.

15 Before applying the enamel to the metallic surface it is prepared by a process known as "setting up." This involves the addition of certain chemicals to the enamel as taken from the mill, the function of this addition being to assist the clay in holding the enamel particles in suspension. Substances so added are termed "vehicles." At this stage the enamel must be diluted with distilled water to the proper consistency for application.

16 In applying the enamel to the metallic surface three general methods are in use: The first, applicable to small pieces only, is known as "dipping," the piece being dipped into the enamel, the excess of which is shaken off leaving a thin coating

on the metal. The second method, known as "slushing," involves pouring the prepared enamel over the surface and allowing it to drain. The third method, which is the principal one used on larger apparatus, involves spraying the finely ground enamel on the metallic surface by means of the compressed air atomizer.

17 Preliminary to the consideration of firing the enamel we may well review the types of furnaces in use. The first type is known as the muffle furnace and involves the use of a large fire clay oven externally heated by means of coal, gas or other fuel. The apparatus to be fired is placed on suitable supports in this muffle. The other type of furnace is known as the direct fire furnace, in which the heat from the fire is taken up by the walls of the firing chamber and radiated to the apparatus placed within the chamber on suitable racks. This general class of furnace has two special divisions in that, on the one hand, the piece is rotated within the furnace, while on the other hand, the piece is allowed to remain stationary. For small work the muffle is in general use, but for the production of large apparatus the direct-fire furnace is necessary. At first thought, the muffle furnace may be considered to have an advantage in that the products of combustion together with the dust from the fire cannot come in contact with the enamel. Again it may seem that a more even heat can be realized in the muffle. On the other hand, with a properly designed direct-fire furnace in which the combustion is complete before the gases reach the firing chamber no trouble is experienced due to their presence or to the dust from the fire. The use of natural gas further does away with this latter possibility.

18 In a furnace for firing smaller ware the charging mechanism is a fairly simple matter, it being necessary merely to place the material in the furnace by means of a small fork operated by hand or mechanically. But in the manufacture of engineering apparatus where a single piece may weigh 3000 to 4000 lb. it is necessary to have a large mechanical charging machine on which the piece may be placed outside the furnace, the arm of the machine then properly placing it in the furnace. The general design of such a machine suggests the charger used in open-hearth practice. The apparatus to which the enamel has been properly applied is placed in the furnace which is maintained at the proper temperature. This temperature varies with the nature of the enamel and in cases of high silicon acid-proof

enamels reaches in the neighborhood of 2500 deg. fahr. The control of the burning is made possible by the changes which occur in appearance of the enameled surface as fusion takes place. At first the fine particles of enamel begin to fuse together and a general blister condition exists, giving the surface a very dull appearance. But as the enamel matures, this dull appearance gives way to a bright glass, which when properly developed over the entire surface is indication that the piece should be withdrawn from the furnace. The time required to burn a piece properly depends upon the temperature of furnace, thickness of metal and nature of enamel.

19 Nothing has been said so far as to the composition of the enamel or of the number of coats applied. In general there are two kinds of enamel, known as ground coats and cover coats. The former serves as a bond between the enamel and the steel, and the latter serves to build up the body of the enamel and presents the finished surface. In the ground coat color is no object. Its composition is such as to render it adherent and strong. In addition to the ordinary components cobalt oxide seems to be essential to the production of adherence. The explanation of this is debatable. The cover coat is the one which forms the major part of the enamel and if definite color, opacity, etc., are objects the necessary ingredients for their production are introduced here, assisted by mill additions as noted above. In the manufacture of acid-proof enamel, the cover coat is essentially a high silicate and must be free from any metallic oxides, such as oxide of tin, lead, iron, etc. The piece to be enameled receives one ground coat which is burnt well into the steel at a high temperature. The cover coats may be one or two in number for ordinary enameling, but should be at least triple for acid-proof work. In the production of acid-proof apparatus, the use of a ground coat or cover coat is now eliminated and the same material which in place of being an enamel, as commonly termed, is in reality a boro-silicon glass and without the use of any metallic oxides in its compounding.

20 It is very interesting to note the chemical changes which take place in the various stages of the production of the finished enamel. Avoiding so far as possible deep technicality, they may be summed up as below. As a starting point let us select a cover coat formula used in the production of a "dark blue" cooking ware enamel.

Feldspar, lb.	120	Saltpeter, lb.	7
Quartz, lb.	72	Oxide of Cobalt, lb.	7½
Borax, lb.	80	Oxide of Manganese, lb.	1
Cryolite, lb.	30	Clay in the mill, per cent	4

First considering the behavior of each of the constituents when heated we can later clearly note the general reactions which take place when they are fused together in the smelter.

21 Feldspar varies greatly in composition but as commonly used in enamels is an aluminum-sodium-potassium silicate of approximately the following analysis:

	Per Cent
Silica (SiO_2)	70
Alumina (Al_2O_3)	17
Soda (Na_2O)	7
Potash (K_2O)	6

On smelting, none of these constituents vaporize so we may consider them all later in the smelting of the above enamel.

22 Quartz introduced as a pure glass sand contains practically 100 per cent silica (SiO_2).

23 Borax is chemically known as sodium tetra-borate and in the crystalline form as used has a certain definite amount of so-called water of crystallization which must be taken into account. The formula $Na_2B_4O_7.10H_2O$ is resolved into $Na_2O.2B_2O_3.10H_2O$. Without going through the calculations assume this to correspond approximately to the following analysis:

	Per Cent
Water (H_2O)	16.0
Boric Oxide (B_2O_3)	37.0
Soda (Na_2O)	47.0

Of these the last two do not vaporize on smelting, but the water is evaporated, hence 100 lb. of borax smelts to 84 lb. of the remaining oxides.

24 Cryolite is a double fluoride of sodium and aluminum, the formula of which may be written Na_3AlF_6. When smelted, the sodium and aluminum appear as oxides and from 100 lb. of cryolite we realize about 24 lb. of alumina (Al_2O_3), 44 lb. of soda (Na_2O) and 54 lb. of fluorine (F_2). There is some dispute as to whether or not the fluorine is vaporized. In the present discussion it matters not, hence we shall consider that the third of these three compounds is lost in smelting.

25 Saltpeter is potassium nitrate KNO_3. When heated under

the conditions of smelting it may be considered to break up into potash (K_2O) and nitrogen pentoxide (N_2O_5). The reaction is $2KNO_3 = K_2O + N_2O_5$. By calculations based on this reaction 100 lb. of saltpeter yields about 47 lb. of potash (K_2O) and 53 lb. of the nitrogen oxide (N_2O_5). The latter may be considered as completely vaporized.

26 Oxide of cobalt (CoO) may be taken as non-volatile and pure. The same may be assumed for the oxide of manganese (MnO_2).

27 To sum up the above as an outline of the reactions taking place in the smelter

120 Lb. Feldspar	gives	$120 \times 0.70 = 84.0$ Lb.	Silica (SiO_2)
		$120 \times 0.17 = 20.4$ Lb.	Alumina (Al_2O_3)
		$120 \times 0.07 = 8.4$ Lb.	Soda (Na_2O)
		$120 \times 0.06 = 7.2$ Lb.	Potash (K_2O)
72 Lb. Quartz	gives	$72 \times 1.00 = 72.0$ Lb.	Silica (SiO_2)
80 Lb. Borax	gives	$80 \times 0.16 = 12.8$ Lb.	Water (H_2O) (Vaporized)
		$80 \times 0.37 = 29.6$ Lb.	Boric Oxide (B_2O_3)
		$80 \times 0.47 = 37.6$ Lb.	Soda (Na_2O)
30 Lb. Cryolite	gives	$30 \times 0.44 = 13.2$ Lb.	Soda (Na_2O)
		$30 \times 0.24 = 7.2$ Lb.	Alumina (Al_2O_3)
		$30 \times 0.54 = 16.2$ Lb.	Fluorine (F_2) (Vaporized)
7 Lb. Saltpeter	gives	$7 \times 0.47 = 3.3$ Lb.	Potash (K_2O)
		$7 \times 0.53 = 3.7$ Lb.	Nitrogen Oxide (N_2O_5) (Vaporized)
7½ Lb. Cobalt Oxide	gives	$7\frac{1}{2} \times 1.00 = 7\frac{1}{2}$ Lb.	Cobalt Oxide (CoO)
1 Lb. Manganese Oxide	gives	$1 \times 1.00 = 1$ Lb.	Manganese Oxide (MnO_2).

We shall consider that of the above the H_2O, N_2O_5 and F_2 are vaporized. This leaves for the constituents of the frit (totals of the above)

	Lb.	Per Cent
Silica (SiO_2)	156.0	53.5
Alumina (Al_2O_3)	27.6	9.5
Soda (Na_2O)	59.2	20.3
Potash (K_2O)	10.5	3.6
Boric Oxide (B_2O_3)	29.6	10.2
Cobalt Oxide (CoO)	7.5	2.6
Manganese Oxide (MnO_2)	1.0	0.3
Total	291.4	

The loss, theoretically, on smelting is plainly $317.5 - 291.4 = 26.1$ lb. or $\frac{26.1}{317.5} = 8.2$ per cent. (317.5 lb. = original weight of batch).

28 The mill additions together with the agents used in "setting up" are fused with the frit as the piece is fired. By a process similar to the above, we could compute the final composition of the enamel by taking these additions into consideration. The actual amount of material added in this case, however, is so slight and of such a nature that the change resulting therefrom is not sufficient to affect materially the composition of the enamel. When an addition of about 12 per cent tin oxide accompanies the clay, a very significant change in the composition of the enamel is produced.

29 It may be well to note in passing some of the means by which various colors are produced in the enameling industries. It will be impossible to enter into great detail without taking too much time, but the mention of certain compounds in connection with the colors produced by their use will serve our purpose.

30 The production of a good white enamel either for cast-iron or sheet-steel work may be said to depend, at the present time, upon the use of tin oxide. Great have been the efforts to substitute less expensive substances, such as compounds of antimony and lead. But an antimony white which looks good alone is plainly seen to be off-color when compared with a good tin oxide white.

31 Going to the other extreme of color, black, we encounter difficulties. There is any number of formulae for black enamels, but when the results are closely compared we find that the colors range widely through brown blacks, blue blacks, purple blacks, etc. Certain compounds of manganese and iron used together give a color approaching black. Other formulae call for the combined use of oxides of manganese, cobalt and copper. Again we find oxide of nickel added to the above three oxides.

32 A color much seen in enamels is blue and the use of cobalt is very satisfactory in the production of this color in various grades of intensity. Manganese alone produces purples and violets and in combination with cobalt gives various shades of purple-blue.

33 Green enamels are chiefly produced by the use of chromium oxide and copper oxide, while in some cases a mixture of copper and cobalt oxide is used.

34 Reds of various shades are produced by the use of red oxide of iron. In connection with it we find that tin oxide aids greatly in giving opacity and bringing out the color. In the

production of brown enamels we may use ferrous chromate. Various yellows are produced by salts of cadmium, chromium and uranium.

35 The more delicate shades of rose and purple are produced by the use of gold compounds. So-called "pink-rose" is used in the manufacture of certain artistic enamels. Perhaps the best known gold compound used in enamel coloring is "purple of Casius." The exact composition of this product is a question. It is made by the combined use of auric, stannous, and stannic chlorides. The color produced is also commonly called "purple of Casius."

36 Before drawing this paper to a close, attention is invited to a general consideration of the future of the enameling industry. Neglecting art enameling and sign making we come to the field of steel enamels. So far as the cooking ware industry is concerned, the field is practically constant. Granting that the demand for that class of article is increasing, as the public becomes accustomed and educated to its use, there is an opposing tendency in the rapidly increasing use of aluminum ware. Exactly how these and other factors now balance would be difficult to ascertain. But aluminum is a metal and its metallic properties cannot be denied. Under certain conditions it is attacked by various substances used in the culinary arts and a contamination of the preparation is inevitable. No doubt the time will come when a high silica enamel known to be free from tin and other poisonous compounds will enter the cooking ware field. The government is becoming more and more careful in protecting the public from foods of injurious nature and it is not too much to expect that soon it will establish more rigid restrictions relative to the ingredients entering into the manufacture of apparatus in which food is to be prepared. At such a time an enamel coming up to requirement will be free from injurious compounds and will come into great demand.

37 In the preparation of foods on a factory scale, we find an enormous and constantly increasing demand for larger pieces of enameled steel apparatus in the form of pans, kettles, tanks, pipe, etc. There are many lines of pressure being brought to bear both by the government and public opinion which lead to the conclusion that the increasing demand for this style of apparatus is without limit. Canning and preserving factories and dairy establishments have found a large use for copper and tin in the construction of containers, vacuum pans, etc. The acids

of fruit juices and vegetable pulps have a very marked action on these metals and the resulting contamination of the product is known to be of danger to the consumer. The use of an enamel containing tin, lead or other metallic oxides is but the first step in the right direction. The presence of these metallic oxides in the enamel renders it corrodible and contamination results. The solution is the use of an acid-proof enamel free from all such poisonous substances. In the milk industry a similar line of reasoning applies. Further compare the case of maintainig sanitary conditions in a one-piece enamel lined unit with the trouble experienced in the use of a metal container or even an enameled article made up of composite parts between which are gaskets.

38 Another consideration relates to the preparation of chemicals later used in food products, for instance, baking powder. Many operations connected with the manufacture of such products have been carried on in lead or other metallic pans and the resulting contamination has given no end of trouble. Acid-proof enamel is rapidly solving this problem also.

39 Finally consider the chemical manufacturing processes now carried on in apparatus of lead, wood and earthenware, necessitated by the corrosive actions of the liquors and gases involved. This includes the pharmaceutical field which alone is a matter of great importance. In all these and many other lines the use of acid-proof enameled apparatus is rapidly finding and filling a great demand.

40 Not only does steel apparatus meet the demands of modern industries, but in case a cheaper product is desired and at the same time a heavier construction is permissible, acid-proof cast-iron apparatus has its field. The possibility for size and variety of construction is, of course, more limited than in the case of sheet-steel apparatus.

41 In view of these considerations and many others which these have called to mind, we cannot but conclude that the use of enameled apparatus has just begun and with this extension of the long known art of metal enameling, a field of great industrial possibilities both for manufacturer and user has been opened. We may not be criticised as being over optimistic when we predict that in their ultimate stage of development the enamel industries will be ranked among the greatest of commercial activities. At such a degree of development the enameling industry will in no way deserve classification among the lost arts.

A NEW CENTRIFUGAL PUMP WITH HELICOIDAL IMPELLER

By C. V. Kerr

ABSTRACT OF PAPER

The reason given for seeking a new type of pump, in view of the fact that standard forms of centrifugal pumps have been so improved in recent years that very creditable performance has been reached, is based on the characteristic behavior of the small steam turbine commonly used to drive pumps for the class of service in view, namely, circulating pumps for condensers in power plants and irrigation or drainage pumps where large volumes of water at low lift are to be handled. Calibration curves for different types and sizes of steam turbines are given showing the relation of power and speed at different steam pressures. Examples illustrating the economy of the high-speed as compared with the low-speed unit are given.

A brief treatment of the mathematical theory of the new type of impeller is presented covering especially features of helical and conoidal surfaces under rotation.

Detailed description of the 8-in. experimental pump is presented with methods and results of tests. Efficiency curves, the capacity of the impeller for centering itself and for maintaining high-suction lift, capacity for handling air leak in suction piping, and comparative behavior of ring-oiling and water-lubricated bearings are fully described.

Tests also on a 30-in. pump are fully described and a method of deriving and locating the parabola of highest efficiency at different speeds for such pumps is explained. In addition to the characteristic curves for this large pump the curve of pressures at different speeds under shut-off, together with the pressure ratio curve is given.

On the basis of these tests a series of pumps was designed and a typical pump in cross-section is shown and described.

The location of the parabola of highest efficiency having been explained, a method of locating it with respect to the friction curve in surface condenser work, which is also a parabola, is presented with mathematical treatment in brief and applied to the case of a pump designed for such service.

A NEW CENTRIFUGAL PUMP WITH HELICOIDAL IMPELLER

By C. V. Kerr, Wellsville, N. Y.

Member of the Society

THE PURPOSE

The progress made in recent years in the performance of centrifugal pumps is gratifying. Pressure pumps suitable for boiler feeding or waterworks service are showing efficiencies as high as 80 per cent at fairly high speeds, and low-pressure pumps at low speeds have shown efficiencies above 60 per cent and even as high as 86 per cent.

2 With many firms building centrifugal pumps with performance like those noted, of excellent construction and running qualities, the use of seeking a new type of pump may be questioned. The reason is chiefly in the characteristic behavior of the small steam turbine which is commonly used as the driving power for the class of service in view, as circulating pumps for condensers in power plants or drainage pumps with low lift and variable speed turbine or motor drive.

3 This small steam turbine is a product of recent years, and it has been making a place for itself rapidly and creditably. Its strong points for power plant service in driving auxiliaries are reliability, clean exhaust-steam for feedwater heating, and small operating expense for attendance and repairs. As part of the power plant, the steam turbine by its oil-free exhaust returns to the boiler through the feedwater heater possibly 90 per cent of the total heat of the steam supplied to it. On the other hand, an electric motor as a driver of auxiliaries, besides being less reliable, represents a waste of probably 85 per cent of the total heat in the steam passing through the main power units into the condensing water.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

4 The turbine operating with steam at high velocity is essentially a high-speed machine. If the turbine were held still, the same total weight of steam would flow through the nozzles as if it were running at the most economical or best speed. To illustrate the relation between power developed by a turbine and rotative speed the following diagrams are used.

5 Fig. 1 shows the calibration of a 12-in. Kerr steam turbine, which was used for tests on pumps within its limits of power and speed. The gage pressure noted on the curves represents

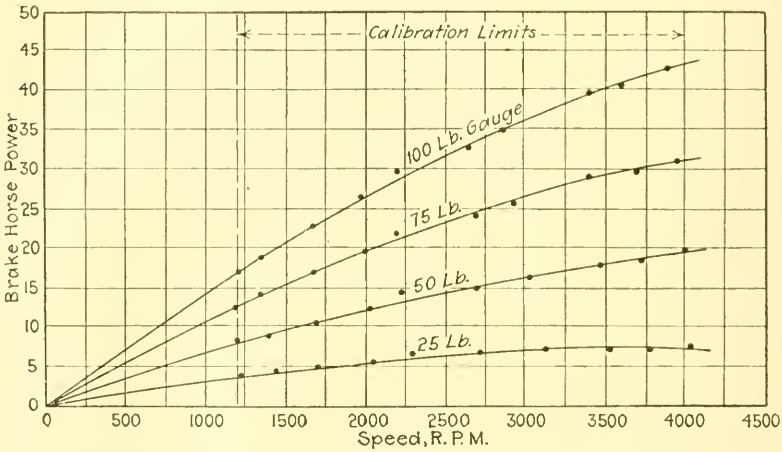


FIG. 1 CALIBRATION OF 12-IN. KERR STEAM TURBINE

the pressure between the governor valve and the nozzles of the first stage. The power developed was measured by a special form of high-speed prony brake, and the back pressure in exhaust was maintained at atmospheric pressure. The limits of speed within which these observations of power and speed were taken are shown on the diagram. If the turbine were to be held fast by this prony brake, obviously no power would be delivered; the calibration curves are therefore properly extended to the origin or coördinates. It should be understood at once that these curves represent a constant steam flow in pounds of steam per hour, although the power delivered varies with the speed. Note that with a constant pressure of 100 lb. gage, the turbine at 1200 r.p.m. delivers 17 b.h.p., while at 4000 r.p.m. 43 h.p. are developed. The same total steam in pounds per hour flows through the turbine in both cases, and

the water rate is inversely proportional to the power developed. Note also that with the lower steam pressures, the power speed curves are flatter than with the higher steam pressures. This means that the turbine reaches its best speed, or speed of greatest economy, sooner with low-pressure steam. This turbine with steam at 150 lb. gage would probably find its best speed between 5000 and 6000 r.p.m.

6 In the same way Fig. 2 shows the calibration of a 36-in.

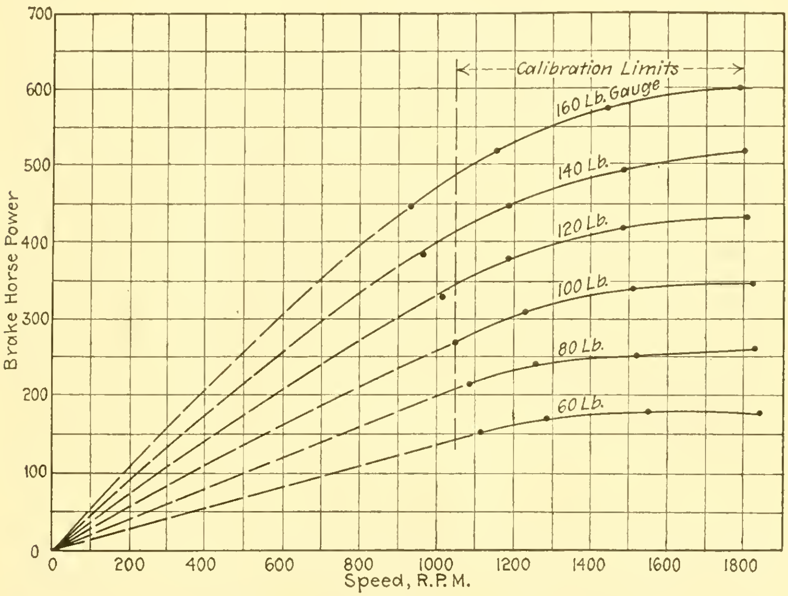


Fig. 2 Calibration of 36-In. Kerr Steam Turbine

Kerr steam turbine used in testing the 30-in. pump to be described later. For the ordinary working range of steam pressure, the best speed of this turbine is found near 1800 r.p.m. On the curve of 160 lb. gage, it will be seen that this turbine at 600 r.p.m. develops about 320 b.h.p., while with the same total steam in pounds per hour at 1800 r.p.m. it develops fully 600 b.h.p. Suppose such a turbine to be driving a pump at 1500 r.p.m. and delivering water at such rate that 350 b.h.p. are required at a pump efficiency of 65 per cent. The curves show that a pressure of 102 lb. on the first stage nozzles would produce the required power. Assume a standard centrifugal pump of 80 per cent efficiency to be doing the same work at a speed

of 600 r.p.m. and requiring 275 b.h.p. The steam pressure necessary is 146 lb. and as the steam flow and first cost are proportional to pressure; the cost of running the high-speed pump will be only 70 per cent of the low.

7 That such behavior is quite characteristic of the steam turbine is indicated by Fig. 3, which shows the calibration of a type *BC* Terry turbine running condensing. Although this turbine with 100 lb. gage develops only 100 b.h.p., its best speed is found to be 2400 r.p.m. This turbine was built to run a 16-in. pump

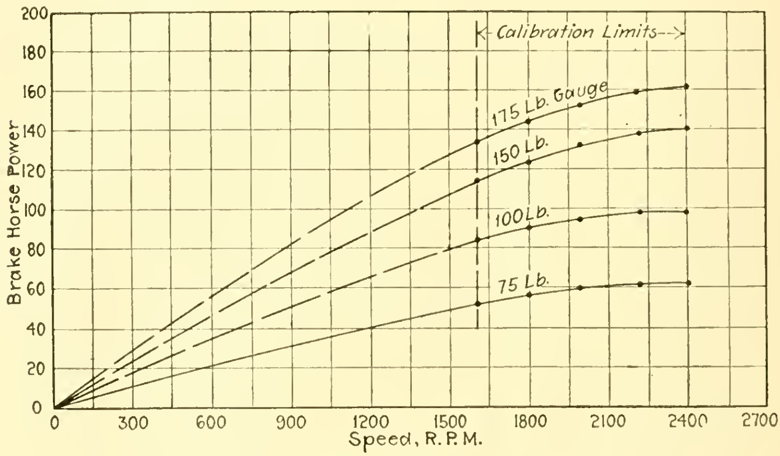


Fig. 3 Calibration of Condensing Terry Turbine

at 2200 r.p.m. at a total head of 35 ft. It is important that both initial and final pressure of the turbine shall be maintained on test of a driven machine the same as when under calibration. If these points are observed, then it is probable that the turbine thus calibrated is for practical purposes as accurate and reliable as a calibrated electric motor, which is much more commonly used for such purposes.

8 The small steam turbine, like the large one, is not worth much without something to drive. In the early days in the development of the small steam turbine, much trouble and some painful experiences were met in securing suitable centrifugal pumps for the steam turbine to drive. The pumps available had been built for use with steam engines or electric motors so far as possible. They were adapted to their speeds either by direct connection or by belt drive. Further, the class of service for

which they were used called generally for cheap construction as well as reliability in service. In the case of high-pressure centrifugal pumps, the conditions of speed were at first good, and improvement has been made both in raising speed and improving the construction. But it is with the low-head or low-pressure centrifugal pumps used for hot-well and condenser service in power plants that the old trouble of low speed and to some extent of cheap construction still obtains.

9 To show something of what a change in speed may mean in power plant service with steam turbine drive, consider a few instances of centrifugal pumps of best construction and performance running at different speeds. Take the case of a pump referred to above; its efficiency of 71 per cent at 1145 r.p.m. is creditable, but if compared with a high-speed pump running at 3200 r.p.m. for the same capacity of 1200 gal. per minute at a head of 50 ft., it will, when driven by the same size of steam turbine, have a total steam consumption in pounds per hour of some 960 lb. greater. Assuming an evaporation by the boilers of 8 lb. steam per lb. of coal under actual conditions, with coal at $3 per ton, the excess of steam by the slow-speed pump will call for 180 tons of coal per year, which at $3 per ton amounts to $540 per year. Again, take the pump with the record efficiency of 86 per cent at 860 r.p.m., which is a typical pump for barometric condenser service. If driven by a steam turbine, it would have a total steam consumption per hour 1060 lb. greater than that of a smaller turbine which could be used to drive a pump at 2000 r.p.m. and handle the same quantity of water, 5500 gal. per minute against 45 ft. head, with an efficiency of only 62 per cent. With the same evaporation and cost of coal, the excess coal required would be worth $600 per year of 3000 hours. Even more extreme cases may be cited. Suppose a pump of 25,000 gal. a minute capacity for condenser circulating water to run at 600 r.p.m. against a total head of 45 ft. As compared with a pump of the same capacity at 1500 r.p.m., the slow-speed pump with an efficiency of 72 per cent as against the high-speed pump at 65 per cent would require with the same size of turbine some 9900 lb. more steam per hour. This under the foregoing assumption means $5570 more per year for coal.

10 It may be urged that the exhaust steam from the turbine can be used for feedwater heating, that it makes no difference what the actual water rate of the turbine or its total steam

per hour may be. But the purpose of a typical power plant is to generate and sell current for power and lighting service. Suppose we consider taking steam from the main turbine at atmospheric pressure for feedwater heating as against using the excess steam from the more wasteful steam turbine auxiliary. In the case of the large circulating pump, the excess steam means some 300 b.h.p. extra. If this steam were used in a main turbine, probably 1 kw-hr. could be developed for each b.h.p. between initial and atmospheric steam pressures. If these 300 kw-hr. are sold at 3 cents per kw. during 3000 hours per year, the total revenue for the station by this saving alone will amount to $27,000 per year. In many power stations, however, the growing use of high vacuum means more power spent on auxiliaries, also better economy in the main generating units. It may very well happen, therefore, that this excess steam must be wasted as atmospheric exhaust. Adding the cost of extra coal and the value of the extra current which could be developed by the main unit, we have $32,570 per year as the difference in the revenue of the station as between wasting and using this extra steam.

11 For such reasons as those stated or indicated in what precedes, and perhaps for other reasons also, the development of a new type of centrifugal pump, especially for low-pressure volume service, which will run at speeds to bring out the best economy of the steam turbine, and therefore of the unit, has been attempted. As part of that purpose a machine which is of the same superior construction and running qualities as the steam turbine has been kept in mind.

THEORY

12 To produce an axial movement of the water a helical or, more properly, a helicoidal surface is assumed. The intersection of the helicoidal surface with a cylindrical surface, concentric with the axis, is the ordinary helix or screw thread. The helicoidal surface is generated by a line, in this case at right angles to the axis, which moves along the axis at a uniform rate while revolving around it also at a uniform rate. The distance traveled along the axis in one turn is called the pitch. The angle made by the direction of the helix on the developed surface of a cylinder of any assumed diameter with the plane of rotation, which is normal to the axis, is called the helix angle.

13 The pitch of the helix is constant for all radial distances from the axis. Let s be the pitch of the helix, a the axial acceleration, and t the time of one revolution. Then $s = \frac{1}{2}at^2$, from which $a = \frac{2s}{t^2}$ and $ma = \frac{2ms}{t^2}$. Hence the impulse imparted is constant for all radial points. In a practical way, this means that water will be picked up at all points from the hub of an impeller to the rim with the same impulse or acceleration and that the axial flow per sq. in. will be constant.

14 To produce the radial flow required to transfer the water

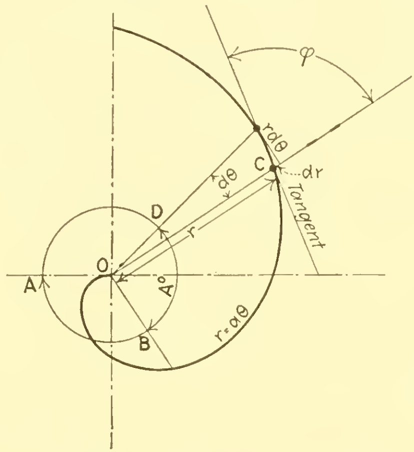


Fig. 4 Archimedes Spiral

from the impeller of the pump to the casing a radial impulse is necessary. In Fig. 4 is shown the arc of an Archimedes spiral which has made part of a turn about the origin at O. The equation of this spiral is $r = a\theta$, in which r is the distance from the center O to any point c on the arc; θ is the arc of unit radius subtending the spiral, or measuring the angle swept by the radius r; and a is a constant. From this equation $dr = ad\theta$; hence the radial acceleration is constant since mdr is constant for uniform rotation. Again the tangent of the angle ϕ between a line passing through two consecutive points of the spiral and the radius to one of these points is $\tan \phi = \frac{rd\theta}{dr}$. But $dr = ad\theta$ and therefore tangent $\phi = \frac{rd\theta}{ad\theta} = \frac{r}{a}$. If $r = 0$, then $\tan \phi = 0$,

which means that the spiral starts radially from the center 0. If $r = \infty$, then $\tan \phi = \frac{r}{a} = \infty$. Hence the spiral finally crosses the radius at right angles.

15 Again from the equation of the spiral, $\theta = \frac{r}{a}$. Comparing this with $\tan \phi = \frac{r}{a}$, the result is $\theta = \tan \phi$. This is true for $\theta = 0$, since $\tan 0° = 0$; also, when finally the spiral is at right

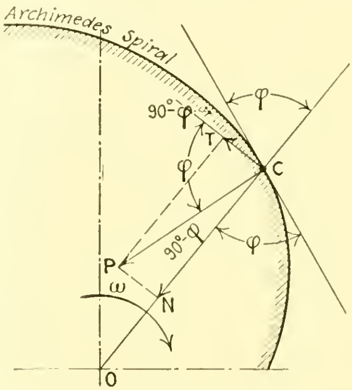


FIG. 5 PRESSURE ON SPIRAL SURFACE

angles to the radius, since $\tan 90° = \infty$. Hence $\tan \phi = \theta$ is the measure of the angle swept by the radius r.

16 To find the angle in degrees of the spiral between assumed radii, $dr = a d\theta$, from which $d\theta = \frac{dr}{a} = \frac{dr \tan \phi}{r}$, in which dr may have any value from 0 to r, and the value in degrees will be

$$A° = 180° \times \frac{d\theta}{\pi} = \frac{180°}{\pi} \times \frac{dr}{r} \times \tan\phi = 57.3° \times \frac{dr}{r} \times \tan\phi$$

17 Suppose a portion of a spiral surface to be rotating with angular velocity ω about a spiral center O, as indicated in Fig. 5, and that a heavy particle at c is free to move under forces acting upon it. The radial or centrifugal force will be

$$N = m\omega^2 r$$

and the tangential force will be

$$T = m\frac{dv}{dt} = m\omega\frac{dr}{dt}$$

since $v=\omega r$ and $dv=\omega dr$. Also from $r=a\theta$, $dr=ad\theta$. Therefore

$$T=m\omega a\frac{d\theta}{dt}=m\omega^2 a$$

since

$$\frac{d\theta}{dt}=\omega$$

Hence

$$\frac{N}{T}=\frac{m\omega^2 r}{m\omega^2 a}=\frac{r}{a}=\tan\phi$$

Now the force T is at right angles to radius r and to force N, therefore the resultant force P is at right angles or normal to the tangent and the spiral, which is the path of the moving particle c. This must be true since angle ϕ of Fig. 5 is a complement of the

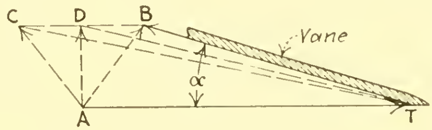


Fig. 6 Entrance Velocities

angle $90° - \phi$. This means that the pressure of the mass c is normal to the spiral surface, regardless of the amount of mass or speed of rotation.

18 Now combine the properties of the helix and spiral by allowing the spiral to follow or lie in the helicoidal surface. As the spiral moves out from the axis uniformly with the rate of rotation, it follows that the spiral in space, if projected on a plane through the axis, will follow the surface of a cone; while, if projected on the plane of rotation, it will appear in its usual spiral form. By this combination, water may be picked up by a helicoidal surface and compelled to flow axially over a conical surface, which gives the fluid a radial component of velocity. Now combine a pair of right and left hand impellers, embodying such helicoidal and spiral properties, and the double suction impeller itself is complete as to fundamental ideas.

19 The trouble found with high-speed propellers used on turbine shafts in the early days of marine propulsion was cavitation, which seems to mean that at a certain rate of rotation the water is unable to follow the wheel or to be picked up by it. Conditions which make for the highest practicable speed of rotation

are indicated by Fig. 6. If the desired quantity of water flows into the impeller with an axial velocity AD and the impeller rotates with a rim velocity AT, the relative velocity will be DT. If the water is directed into the impeller against the direction of rotation, as at AC, the relative velocity will be increased to CT. If directed into the impeller in the direction of rotation, as at AB, then this relative velocity is reduced to BT, and at the same time the angle of the helix is increased. For such reasons the suction inlet to the pumps, which naturally must be closed, is made in volute or spiral form directing the water into the impeller in the direction of rotation.

20 The diagram of discharge conditions at the rim of the

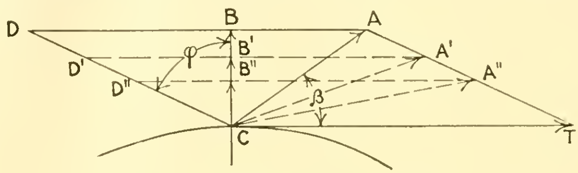


Fig. 7 Discharge Conditions

impeller is indicated in Fig. 7. It will be noted that, as the radial velocity of discharge CB decreases, the absolute direction of discharge CA makes a smaller and smaller angle with the tangent CT to the impeller. This change of discharge angle makes trouble with the diffusion vanes commonly used in centrifugal pumps and causes loss of efficiency through eddies. As the pumps in view are to be of the low-pressure volume type, it is possible to dispense with the diffusion vane and use instead an annular nozzle surrounding the impeller through which the fluid may be discharged and reduced in velocity to terminal pressure, as in the case of water flowing through the delivery tube of an injector. In Fig. 8 are shown the essential parts of a pump drawn to scale from a design in which the spiral or volute suction passage is indicated, also the annular nozzle surrounding the helicoidal impeller. The direction of rotation of the impeller is indicated; and also the movement of water outward through the wheel and an assumed spiral path along which the particles of fluid pass from impeller to volute casing. By plotting distances along this spiral path against the radial distances from the axis and the axial width of the annular nozzle, the effective or actual length of nozzle is increased and indicated

by the dotted lines and arrow in the left-hand portion of the figure.

21 It was shown in connection with Fig. 5 that the pressure on a particle following a spiral path is normal to it. Since the particle discharged from the impeller through such an annular nozzle moves as a free body under the forces acting the assumption is made that such a particle will tend to follow a spiral path out into the volute. The velocity of discharge from an impeller will vary widely with speed, capacity and head, so that the actual

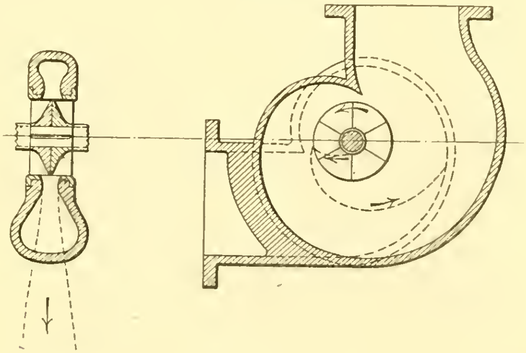


FIG. 8 VOLUTE CASING SHOWING AUTOMATIC CHANGE OF EFFECTIVE NOZZLE LENGTH

form of the annular nozzle must be a compromise. In general, as the capacity decreases, the velocity of discharge will increase, and the direction of discharge will make a smaller angle with the tangent to the impeller; but, fortunately, the smaller the angle which the direction of discharge thus makes, the longer will be the effective spiral path through the nozzle to meet the demands of the higher velocity. Thus the annular nozzle in a way automatically changes to meet more or less closely the conditions of operation.

8-IN. EXPERIMENTAL PUMP

22 The first step in the development of an idea is to fix upon the best way of carrying on the work under existing conditions, which in this case means facilities for construction and testing. For such reasons, the experimental pump shown in Fig. 9 was decided upon. In view of the avowed purpose of these pumps to work with condensers as circulating and hot-well pumps, and with steam turbines as the motive power, an 8-in. pump with a

speed of about 3000 r.p.m., a total head of from 30 ft. to 40 ft., and a maximum efficiency near 1200 gal. per min. was designed. Provision for getting the results of various combinations of impellers and annular nozzles was provided as indicated in Fig. 10 at *A* and *B*. As seen from the photograph in Fig. 9 the casing is split; and as part of the program, the flanges were planed off to reduce the nozzle width, as indicated at *A*, Fig. 10, after it had passed through the changes in form numbered 1, 2, and 3 shown

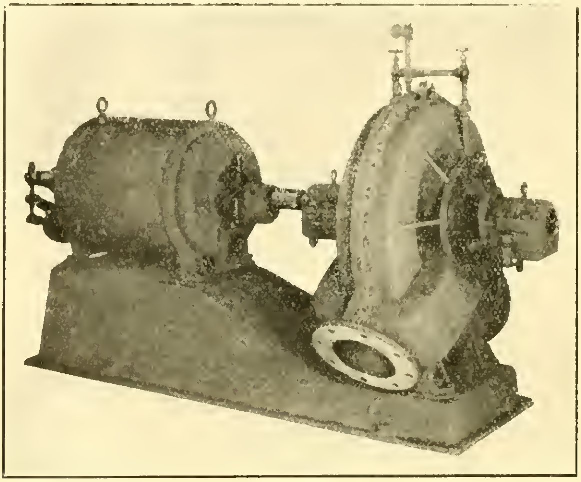


Fig. 9 Experimental 8-In. Pump

at *B*. Various forms of impellers were also used. The result of the first effort at designing, pattern-making, casting and machining was an efficiency of only 33 per cent. Indications of what changes should be made were obtained, however, and steady progress was made with some determination of what should and what should not be attempted.

23 With a double suction impeller, having six right-hand and six left-hand blades making an angle of 15 deg. with the plane of rotation and a diameter of 6½ in. for this 8-in. pump, the results in Fig. 12 were obtained. A pressure regulator of the spring-loaded type was used to control the speed of the turbine to secure constant head. For the head of 31 to 34 ft. the speed began at 3600 r.p.m. and ran down to shut-off at 2000 r.p.m. For a head of 21 to 24 ft., the speed began at 2850 r.p.m. and ran down to shut-off at 1625 r.p.m. The turbine used to drive this 8-in. pump is one whose calibration is shown in Fig. 1. The

effect on the efficiency curves of the pump itself is to make them longer and flatter than if the speed were maintained constant. The efficiency of the turbine as measured by power delivered for a given flow of steam will also be maintained higher. This brings out one of the strong points of steam turbine drive for centrifugal pumps, a variable speed easily and economically controlled.

24 The arrangement for testing this 8-in. pump is shown in Fig. 11. The concrete tank, with a capacity of 6500 gal. under

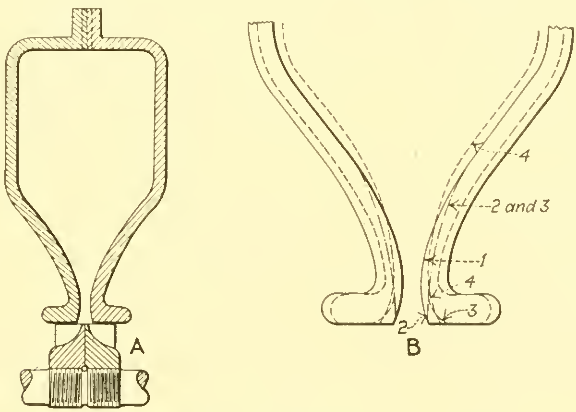


Fig. 10 Annular Nozzle of 8-In. Pump

working conditions, was put down and a frame work of I-beams put over it to support flooring and apparatus. Attention is called especially to the partitions which compelled the water discharged from the nozzle to pass first over a partition, then under and finally over the last partition to the suction compartment. The water in the first or discharge compartment was churned into foam by the jet issuing from the nozzle; but when it arrived at the suction compartment in the course of operation it was quiet and to all appearance free from air, except the amount usually dissolved in water. The other features in the arrangement for testing will be readily seen, although it should be added that ½-in. pipe connections were made in order to test the capacity of the pump to handle air leaking into suction. The head gage shown is a water column with a total available range of 15 ft.

25 The pump was arranged with adjustable thrust collars in the outer bearing case. These collars could be put in the de-

sired position and were self-locking by right and left hand threads. The pump could therefore be run, either held in a fixed position by these thrust collars or left free to take its own position. This is a characteristic of the helicoidal impeller. From the construction, Fig. 10 *A*, it will readily be seen that if the shaft is moved to the right for instance, the discharge head on that side will increase while the capacity and suction on the opposite side will also increase. This makes a positive force

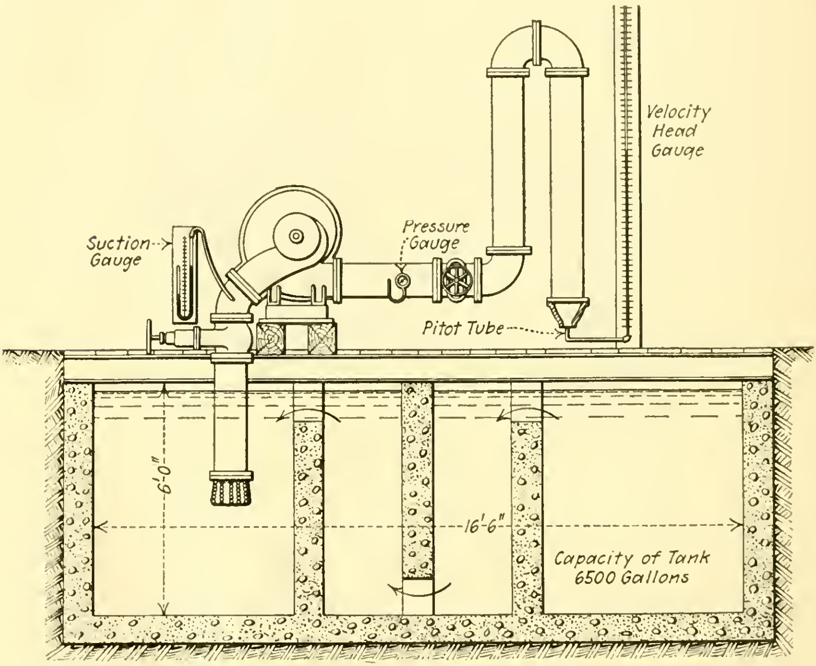


Fig. 11 Testing Tank for 8-In. Pump

tending to bring the impeller back to central position and keep it there. This feature of the pump was repeatedly demonstrated in the course of tests made on it.

26 In testing the capacity of the pump to handle air leakage, the ½-in. pipe connections, first on one suction passage, then on both were operated. The effect of a full ½-in. opening into the suction with a suction lift of about 6 ft. was to lower the normal discharge head from 30 ft. to 20 ft. This condition would be steadily maintained until by clapping the hand over

the air opening the discharge head would instantly rise to 30 ft. and remain there. This showed that the pump could handle the large amount of air leakage, and also quickly get rid of air carried in. The ½-in. air opening in one side of the suction passage was also operated, with the result that the impeller would jump toward the opposite side of the pump in the effort to adjust the work done by the two sides of the impeller. On closing this air leak, the impeller would promptly return to the normal central position.

27 By throttling the suction the capacity of the pump to lift water was indicated. The elevation of Wellsville is about 1500

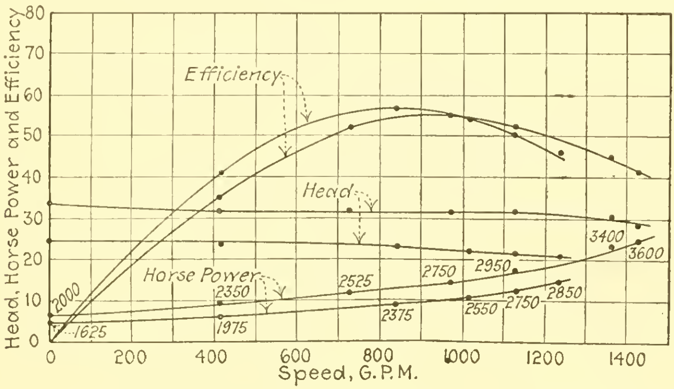


Fig. 12 Tests on 8-In. Pump at Constant Head and Variable Speed

ft. above sea level, and normal barometer stands about 28.3 in. At a speed of 3700 r.p.m. and discharge head of 10 ft., with a small amount of discharge from the pump and the barometer standing at 28.05 in., the vacuum maintained by the pump, as measured by mercury column referred to the center of the shaft, on one test was 26.9 in. This corresponds to a lift of 30.4 ft. against a limit of 31.7 ft. fixed by the barometer. On another test with a different runner, with barometer standing at 28.1 in. and speed of 3500 r.p.m., the vacuum was maintained in the suction of the pump at 27.0 in., which means a lift of 30.5 ft. against a limit of 31.8 ft. fixed by the barometer. At 3040 r.p.m., the vacuum in the pump suction was maintained at 26.2 in. The highest vacuum reached could be steadily maintained at speeds as high as 4000 r.p.m.

28 The results of tests on the last combination of impeller

and nozzle are shown in Fig. 13. It is true that the results here shown do not reach as high points as those obtained from previous tests on other combinations. But it is difficult, naturally, to change impeller widths and nozzle forms successively and stop with all things in the best shape. In the meantime, also, the form of pitot tube had been changed to give more nearly correct results, and a water column had been substituted for a calibrated low-pressure gage for the pitot tube readings. The coefficient of discharge from the nozzle was assumed to be unity

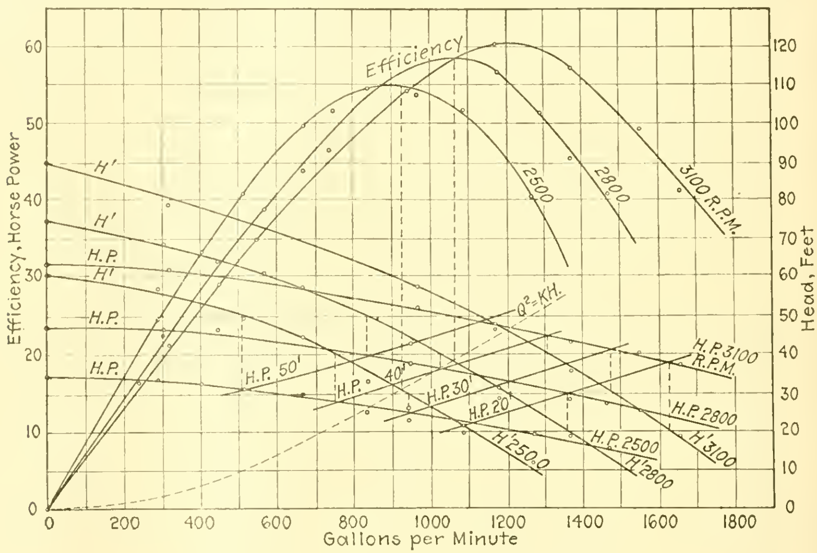


Fig. 13 Final Results on 8-In. Pump

throughout. This is justified by results obtained on nozzle calibrations at a university laboratory, and any doubts as to this point are partly balanced, at least, by the fact that the turbine driving the pump was calibrated by the builders with high-pressure steam and ran on these tests with low-pressure steam. In each case, however, the steam was passed through separators, but of different makes.

29 Most of the characteristics of the pump will readily be seen from the diagram. It would have been interesting to run another test at higher speed to see how far up in speed the efficiency of the pump would increase, but the boiler power available did not permit. The diagram indicates, among other

things, the horsepower at constant speed and also at constant head. An interesting feature in these results is brought out by the application of the equation of a parabola $Q^2 = KH$, derived as follows: $Q = AV = A\sqrt{2gH}.$ Then comparing two conditions,

$$\frac{Q}{Q_1} = \frac{A\sqrt{2gH}}{A\sqrt{2gH_1}} = \frac{\sqrt{H}}{\sqrt{H_1}}$$

from which

$$Q^2 = \frac{Q^2}{H_1} \times H = K\,H$$

This curve will be seen to cross the head capacity curves at points

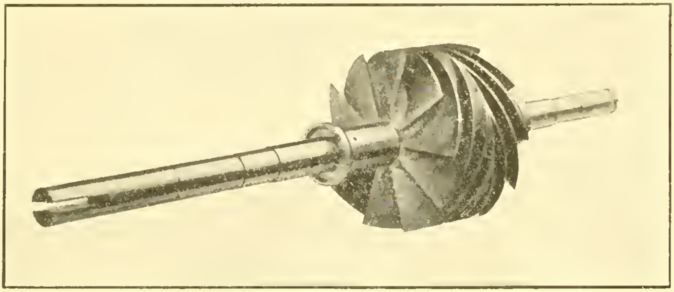


Fig. 14 Impeller for 30-In. Pump

which correspond to the highest efficiency reached at the different speeds. This permits prediction to be made as to head, capacity, and position of highest efficiency for other operating conditions. If in addition to this information, the envelope to these efficiency curves could be determined by more extended tests, then the actual maximum efficiency, corresponding to any speed, capacity and head within range of the pump could be fixed. This envelope will have the same general form as the efficiency curves: but it will be longer and flatter than any of them.

30 It may be interesting to add that, as a sort of side issue, metallic packing rings in the glands were tried against the ordinary lubricated flax packing. The metallic packing ran cooler and with a steady drip of water through it, which maintained the best possible working conditions. and it was found that the shaft was polished nicely under this packing. The material used was ordinary type metal made in solid V-shaped rings,

which were a close running fit on the shaft and backed by soft packing. On the other hand, the flax or hydraulic packing gave frequent trouble through need of adjustment to secure the proper compromise between heating and leaking. Also, a water lubricated bearing of type metal arranged for water from the discharge of the pump to flow through it into the suction was tried against the usual ring oiling bearing. Tests by micrometer caliper showed that the oil bearings wore the shaft more than

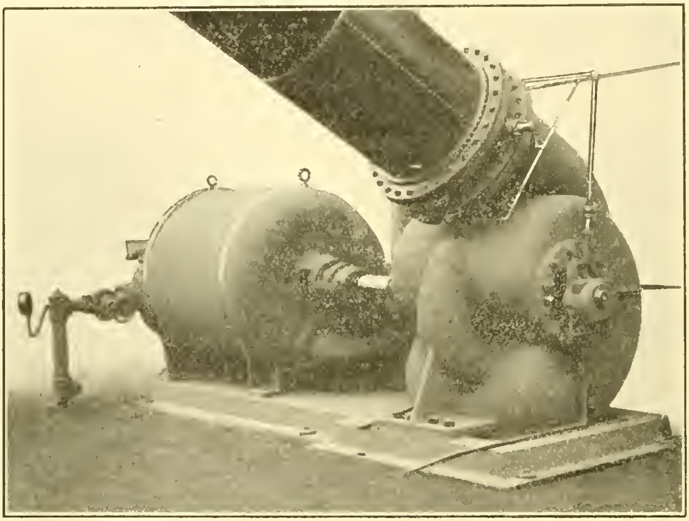


Fig. 15 Thirty-Inch Pump

the water bearing did. This water bearing was also arranged so that a mixture of sharp sand and water could be drawn through it into the suction passage of the pump. What such treatment would mean to a ring oiling bearing needs no comment. The water bearings stood the treatment very well.

30-INCH PUMP

31 Apparently justified by the results on the 8-in. experimental pump, the opportunity came and was accepted to build a pump of this type with the maximum capacity of 30,000 gal. at 45 ft. total head for service as a circulating pump with a large condenser. A photograph of the impeller is shown in Fig. 14. This is one of three different impellers having different numbers of blades and helix angles that were built and tested with this

pump. In this case the runner has 10 blades with the helix angle of 20 deg. The other runners were of 5 and 8 blades with helix angles of 20 deg. and 17½ deg. respectively.

32 The pump with the turbine driving it is shown in Fig. 15. The suction was vertical and the discharge 30 deg. from the horizontal. This arrangement of the pump was required by the location between the foundations of two large units which made it necessary to discharge directly into the water box of the condenser. The turbine is the one whose calibration is given in Fig. 2.

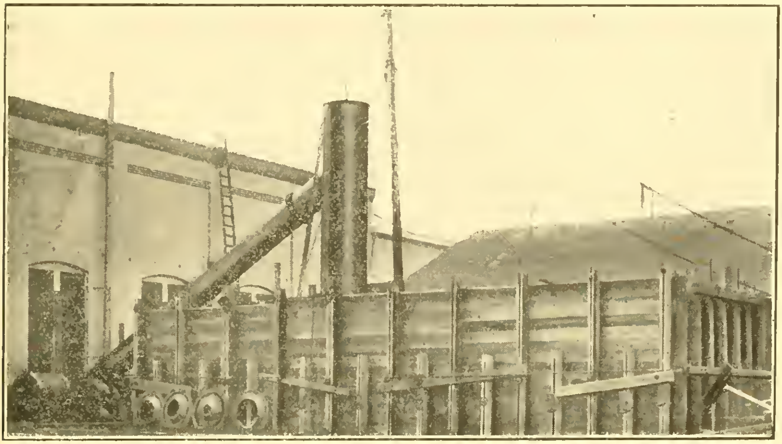


Fig.1 6 Testing Tank for 30-In. Pump

33 On account of the unusual size of this pump and the desire to learn as much as possible of its performance under different conditions, somewhat elaborate arrangements were made for testing it. A general view of the testing tank used with the turbine and pump, discharge pipe and standpipe is given by Fig. 16. The suction and discharge connections are 30 in. and the standpipe is 48 in. Two glass water columns are shown on the side of the standpipe, one for velocity head as measured by the pitot tube and the other for static pressure at the level of the nozzle. Some of the nozzles used are seen standing against the side of the testing tank.

34 The tank has a capacity under working conditions of about 45,000 gal. The water flows continually around or through the apparatus and the direction of flow in the tank is

such as to free the water of air as completely as possible. It was very effective and the water returned to the suction inlet completely freed from air, except that dissolved. This tank was designed and built after some runs had been made with a round tank holding some 12,000 gal. of water with a vertical partition in the middle to force the separation of air bubbles entrained by

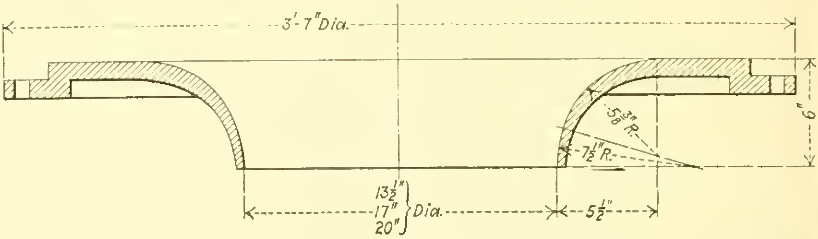


Fig. 17 Nozzles for 30-In. Pump Test

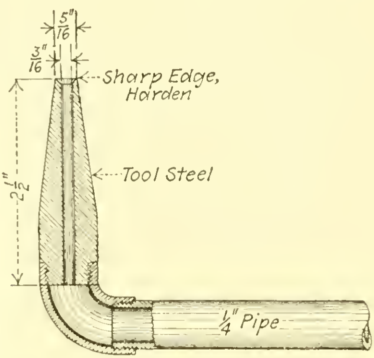


Fig. 18 Form of Pitot Tube

the jet of water from the standpipe; but this amount of water furnished only a half minute's supply at full capacity and in operation the tank became so full of foam that air bubbles reached the suction pipe and apparently occasioned efficiencies incredibly high.

35 A calibrated test gage was used to determine the steam pressures at the turbine and a calibrated portable tachometer was used to determine speeds. Mercury columns were used to measure the suction and discharge heads. The suction column was connected to both sides of the pump. The discharge column was connected to the discharge pipe at four points with valves

in each branch to detect any differences in head due to the different positions; but any differences which may have existed were covered by errors of reading.

36 Three nozzles of size and form as in Fig. 17 were provided. In this case a coefficient of 0.97 was used which is thought to be sufficiently conservative. Three sizes of pitot tube of form given in Fig. 18 were used. The material was tool steel and to

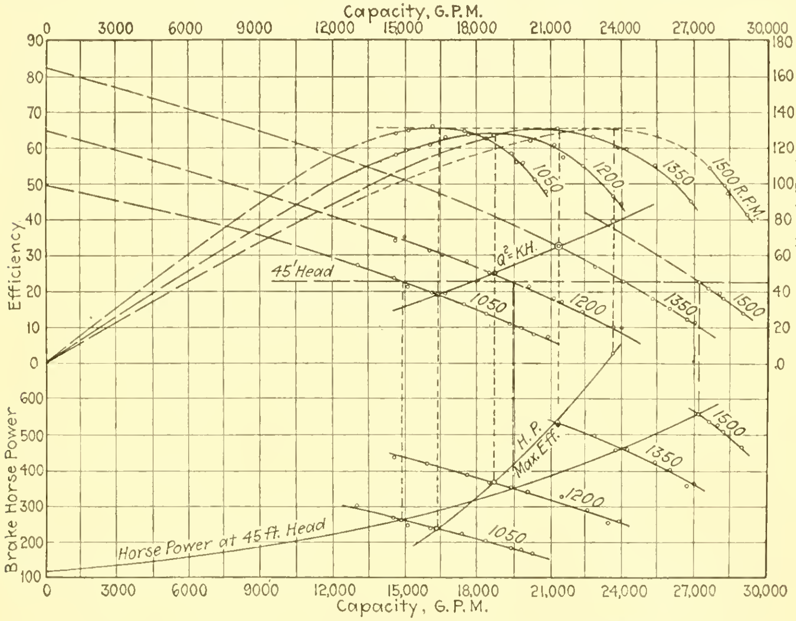


Fig. 19 Results of Tests on 30-In. Pump

prevent damage during the tests, the edge was made sharp and hardened. One smaller and one larger size than that shown were tried under similar conditions, but the $\frac{5}{16}$-in. tip was used as giving the best combination of sensitiveness and steadiness of water column. The static water column was used to check the pitot tube readings and when both were in proper working order and due allowances were made for connections and velocity heads, the agreement between the two sets of readings was very close. The advantage of the static water column as a safeguard was repeatedly shown during the tests. Occasionally a small piece of shaving or fiber of some kind would lodge on the tip of the pitot tube and lower its water column to such an extent as to

require immediate attention. This condition which might not otherwise have been noted quickly was always shown at once by comparison with the static water column.

37 The general results of reliable tests are set forth in Fig. 19. Although the boiler plant which furnished steam for these tests was of the water-tube type of 400 h.p. rating with available steam pressure of 200 lb. gage, it was found impossible to maintain maximum working power for any length of time and the contemplated range of tests was curtailed in consequence. A considerable amount of steam necessarily had to be used for shop

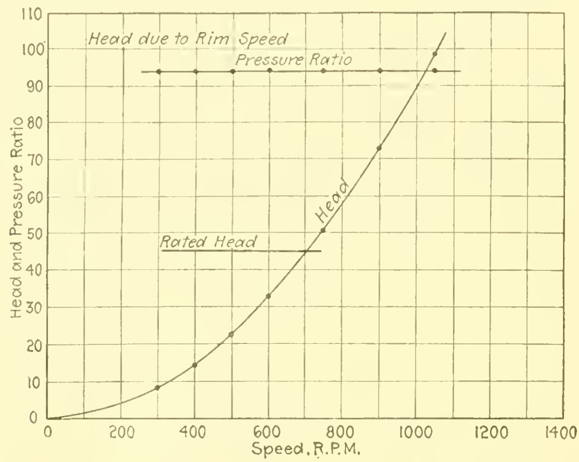


Fig. 20 Shut-Off Pressures in 30-In. Pump at Variable Speed

driving and driving auxiliaries with some routine testing at the same time. In general, the form of curves with difference in scale is very much like those obtained from the 8-in. pump. Although the head and horsepower curves rise somewhat rapidly, the horsepower for the constant rated head of 45 ft. falls rapidly with the decrease in capacity. In surface condenser service, especially where the discharge pipe as well as the suction pipe is sealed by water, the working head is largely due to friction in pipes, valves, and condenser tubes. It follows, therefore, that the head in operation will actually increase with the capacity of the pump. The power required will, therefore, vary under actual conditions even more rapidly than with constant head. This is illustrated in Fig. 19 by the line marked horsepower at maximum efficiency.

38 The efficiency actually reached is thought to be creditable, considering the fact that this is the first large pump of the type to be built and that the speed is much higher than is ordinarily attempted with centrifugal pumps under like conditions of head and capacity. The effect on the unit consisting of turbine and pump as to steam per water horsepower may be readily guessed by comparing the power developed by the turbine at speeds of 1200 and 1500 r.p.m. with that at 600 to 800 r.p.m. when combined with such efficiencies as were actually secured.

39 Some interesting information in regard to the behavior of this type of impeller at shut-off or no-discharge is conveyed by the diagram in Fig. 20. With a blank flange in the discharge pipe from the pump the turbine was run at different speeds and

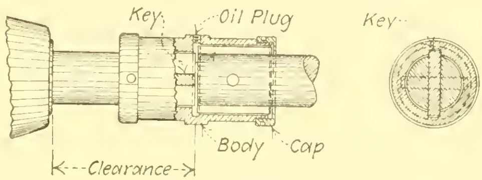


Fig. 21 Lubricated Flexible Coupling

the corresponding total head in feet of water observed. The rated head of 45 ft. was obtained at 700 r.p.m. The lower pressures on this curve were obtained by the mercury column and the higher pressures by the calibrated test gage. The head due to rim speed is figured from the rim velocity of the impeller at different speeds. The pressure ratio line shows the relation between the head actually observed and that due theoretically to rim speed. To find this ratio practically constant at about 94 per cent was somewhat of a surprise.

40 The desire to make the design of the pump such that the impeller and shaft could be withdrawn endwise from the casing made it necessary to design some other form of flexible coupling than the commonly used flanged rubber bushing type. The result is shown in a general way in Fig. 21. The essentials of this coupling are a pair of flat tool-steel hardened keys set in the adjacent ends of the shafts at right angles to each other. The power is transmitted from one to the other through a crucible cast-steel body which is closed at each end by a cap which screws tight against a shoulder. Through the oil plug indicated, a

heavy lubricant is put into the coupling, such as cylinder oil or machine oil mixed with graphite. The spaces in the coupling may be filled with this oil until it begins to run out at the shaft

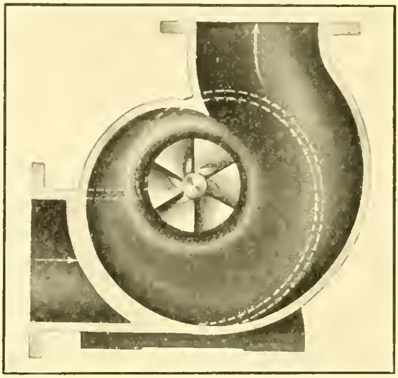


Fig. 22 Typical Section of Pump Casing

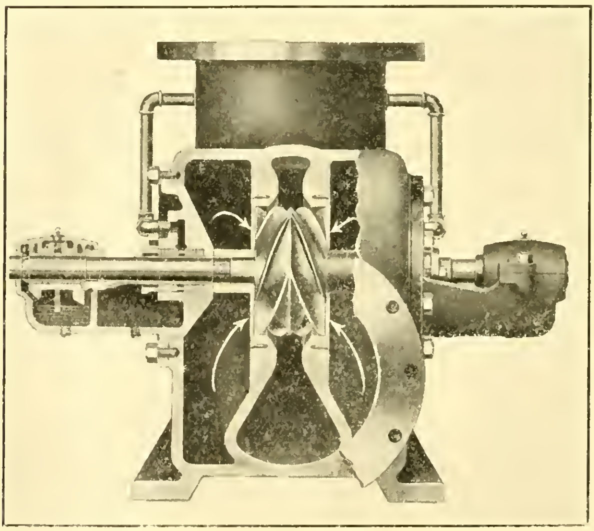


Fig. 23 Section of Pump showing Helicoidal Impeller in Place

level. In operation, the centrifugal force throws this oil out into the grooves where the keys are bearing on the body. The object of hardening the keys is to maintain the form of the key and to put all the wear on the soft steel body of the coupling. By re-

moving one end cap, the shaft may first be withdrawn far enough to drive out the straight pin used to hold the key in central position, which permits the removal of the key and then the impeller from the casing. To illustrate the capacity of this coupling, one size is 4 in. in diameter, weighs 15 lb. and transmits at 2400 r.p.m. a maximum of 300 h.p. with safe working stresses.

TRAITS OF THE HELICOIDAL PUMPS

41 Upon the basis of information obtained from such tests as the foregoing, and from observation of running qualities, a

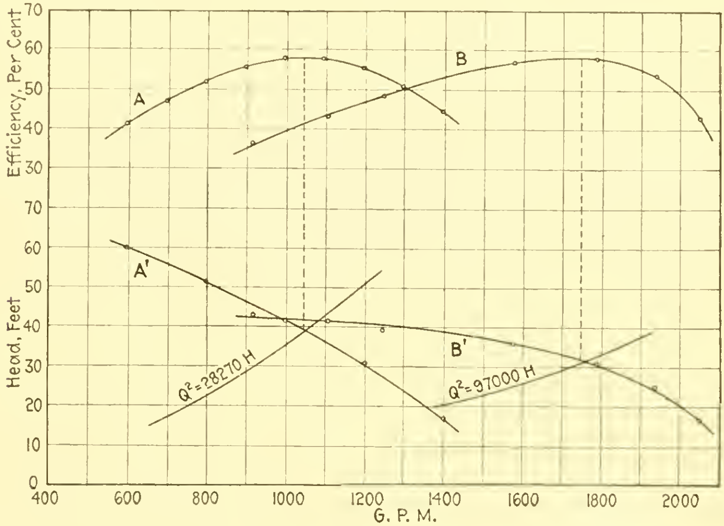


Fig. 24 Changes due to Difference in Impeller Design

series of pumps was designed. A typical section is shown in Fig. 22. An effort was made to mold the interior of the pump casing so that the water would change velocity and direction smoothly and with a minimum of eddy losses. The best position, however, of the cut-off is an uncertain matter. The intention is so to locate it that throughout the range of change in direction of water discharged from the impeller, there will be no eddy losses occasioned by the direction of stream lines crossing the cut-off. In the dotted lines, the general form of the volute suction inlet is shown. The initial advantage of this helicoidal type of runner is well set forth in the end view. The edges of the blades can be spaced and machined accurately and water can be taken into the impeller from the hub to the rim.

42 In Fig. 23 the elevation is partly shown in section. The feature strongly emphasized in the design of this pump is the ability to withdraw the impeller and shaft endwise from the casing simply by removing one bearing head. As compared with the split casing type of pump, this construction permits the suction and discharge to be located at any direction required by circumstances. Also, it frequently happens, as in the basement of a power plant or in cramped quarters on shipboard, that crane service is not available. This would make it difficult to remove the top half of a casing, while two men can handle the shaft and impeller even of a 30-in. pump of this type.

43 Of details of construction as shown in Fig. 23, the throat

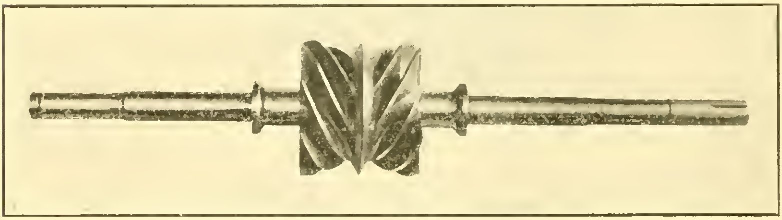


Fig. 25 Typical Notched Impeller

rings are of bronze, the sleeves on the shaft are locked right and left to hold the bronze impeller in any desired position and to prevent rusting of the shaft by the fluid pumped. The water discharged from the pump is used to seal the glands and prevent air drawing into the suction passage. The bearings are ring oiling with split babbitt-lined bearing shells. The design of the impeller permits balancing which is practically perfect, both at rest and running. This balance is not destroyed by the stresses set up by rapid rotation. The result has been that in the pumps so far constructed, the bearings ran with even less tremor or vibration than the bearings of the turbine used to drive them.

44 Something of the changes in pressure capacity curves which may be secured by suitable impeller design is shown by Fig. 24. The curves AA' and BB' result from a rim speed due to 3000 r.p.m. for a 6 in. diameter and a difference in helix angle and radial depth of blade. Theoretically, the parabola $Q^2 = KH$, may lie anywhere in the quadrant.

45 With the ordinary centrifugal impeller, change of capacity at a given head and speed is obtained by width of discharge

opening; in the helicoidal, the helix angle may be changed, greater capacity resulting from a greater angle. Change of head at a given speed and capacity may be obtained from the centrifugal impeller by change of blade angle at discharge or of diameter; but in the helicoidal, by notching as illustrated by Fig. 25, and if the relations of helix angle and depth of notch are suitable, the efficiency is increased by notching. Leakage back into suction is reduced by the screw conveyor effect of a short cylindrical portion at either side revolving within the throat

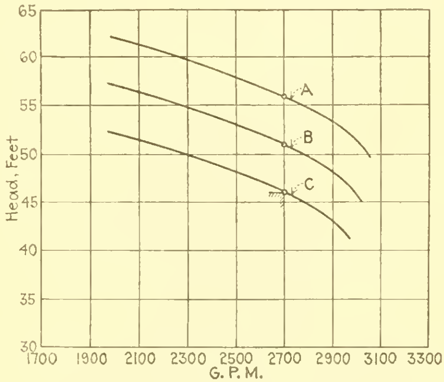


Fig. 26 Changes in Head at Constant Speed and Efficiency due to Notching Impeller

rings. The curves A, B and C of Fig. 26 show the result of beginning with the full helicoid and notching successively to obtain the rating of 2700 gal. per min. at 46 ft. head and the constant speed of 3000 r.p.m. The maximum efficiency was obtained at rated capacity throughout.

46 With the same axial inlet velocity assumed, the helicoidal impeller lies within the eye or inlet opening of the centrifugal. Then by notching deep with small helix angles, relatively low head and large volume may be obtained with good speed and efficiency. The general appearance of one form of such a pump is very well presented by Fig. 27, for which the impeller shown in Fig. 25 was constructed.

47 The derivation of the parabola showing the relation of head and capacity at maximum efficiency has already been explained. Reference has also been made to the fact that in surface condenser work where suction and discharge connections

are submerged, the total head may be entirely due to friction in tubes and piping. The general equation for friction head is $F = f\gamma s \frac{v^2}{2g}$, where $\frac{v^2}{2g}$ represents a *height;* as s is an area, $s.\frac{v^2}{2g}$ is a *volume;* and $\gamma s.\frac{v^2}{2g}$ is a *weight.* Then f is a numerical coefficient expressing the ratio of the force F required to overcome the friction of the weight on the surface. With area in sq. ft. and weight in lb., F is naturally expressed in lb.; but 1 lb. pressure per sq. in. is produced by a height of 2.31 ft. of water, and f may be replaced by f' so that the frictional resistance is finally

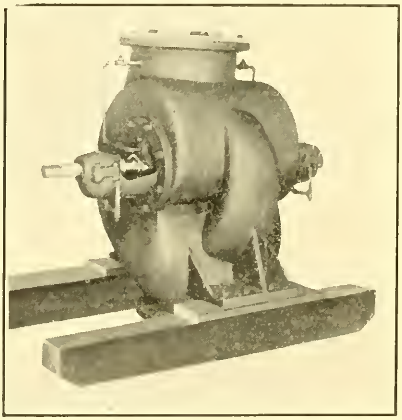


Fig. 27 Twenty-Inch Circulating Pump

expressed as a total head in ft. Then solving $v^2 = \frac{2gF'}{f\gamma s} = K\,F'$, which is also the equation of a parabola. Now the capacity Q in gal. per min. is proportional to velocity v in ft. per sec. which produces the friction head. Hence if the parabola of head and capacity has a point in common with the friction parabola, they must coincide throughout as they have a common origin at zero head and capacity.

48 Assume that a maximum capacity of 11,000 gal. per min. is required at a total friction head of 20 ft. From this $K = \frac{11{,}000^2}{20} = 605 \times 10^n$, for slide rule calculation; and by assuming values of Q in $H = \frac{Q^2}{K}$ the head capacity parabola of maximum

efficiency in Fig. 28 may be determined. This may be associated with the 20-in. pump of Fig. 27 running at 1640 r.p.m., and such a pump properly fitted to conditions will operate at maximum efficiency regardless of actual speed and capacity.

49 But suppose the total friction head were found to be 15 ft. instead of 20 ft. Then the unit designed for 20 ft. head would deliver the required 11,000 gal. per min. at a speed of 1540 r.p.m. and an efficiency of 62 per cent instead of the maxi-

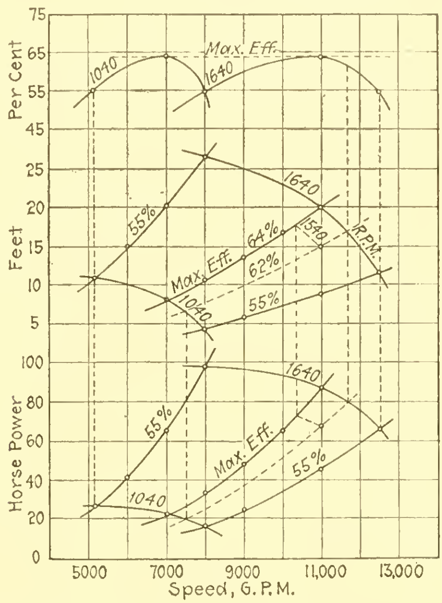


FIG. 28 PERFORMANCE CURVES FOR A CENTRIFUGAL PUMP AT MAXIMUM EFFICIENCY WITH VARIABLE SPEED

mum of 64 assumed. The dotted lines of Fig. 28 indicate the relative changes. Observe at this time that along these parabolas, whether of maximum efficiency or otherwise, the capacity varies with the speed, the head with the square and the power with the cube of the speed. And also that, if the submerged suction and discharge water levels are not at the same elevation, the parabolas of friction and of total head not having the same origin could not be made to coincide throughout.

50 In barometric condenser service and in irrigation and drainage work the friction head is of less importance. More

attention must be paid to large variation in static head. And for such work the rapidly varying head capacity curve characteristic of the high speed pump marks that type especially useful.

The data for the 8-in. and the 30-in. pump curves, Figs. 13 and 19, were obtained from tests conducted by Mr. Geo.A.Orrok, mechanical engineer for the New York Edison Company and his assistant engineers. The plan of testing the 30-in. pump was also approved by Prof. W. T. Magruder of the Ohio State University, and tests were witnessed by him. Duplicate tests were afterwards witnessed by Capt. F. H. Bailey, U. S. N.

TESTS UPON THE TRANSMISSION OF HEAT IN VACUUM EVAPORATORS

By E. W. Kerr

ABSTRACT OF PAPER

This paper deals with a series of tests made at the laboratories of the Louisiana State University to determine the effect of hydrostatic head, density of heating steam, incondensable gases in the heating steam, density of the liquid being boiled, design of the heating compartment, etc., upon the transmission of heat in vacuum evaporators of the kind used in the sugar and other industries.

The tests were made upon an apparatus designed especially for the experiments. Five different designs of heating compartments varying as regards tube dimensions, tube arrangement, circulation of juice, steam distribution and manner of removing incondensable gases were tested.

Some of the fundamental principles concerning the design and operation of multiple evaporators are discussed in the paper. It includes also various curves and tabulated data giving the results of the tests.

TESTS UPON THE TRANSMISSION OF HEAT IN VACUUM EVAPORATORS

By E. W. Kerr, Baton Rouge, La.

Member of the Society

The object of the tests described in this paper was to secure experimental data regarding the effect of the different factors which influence the transmission of heat in vacuum evaporators.

2 After making a number of tests on multiple evaporators in sugar factories it was concluded that a special experimental plant would have to be constructed for testing purposes, in order to control the conditions of operation. Accordingly, an apparatus was designed and built and, although considerably smaller than the average commercial machine, was large enough to give results comparable with what might be obtained from units of commercial size. This apparatus was erected and operated in the mechanical laboratory of the Louisiana State University and Audubon Sugar School.

3 The transmission of heat through the tubes of evaporators is affected by the following factors:

a Velocity of juice circulation
b Distribution and velocity of the heating steam
c Presence of incondensable gases in the steam compartment
d Hydrostatic head of the boiling liquid upon the heating surface
e Presence of condensed steam upon the heating surface
f Density of the liquid being concentrated
g Cleanliness of the heating tubes

4 *Velocity of Juice Circulation.* The circulation of liquid in most evaporators is not positive, but depends upon convection currents much the same as in steam boilers, steam tube evapora-

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

tors being analogous to fire tube, and liquid tube evaporators to water tube boilers in this respect. In view of this fact it is evident that the advantages of high velocity of circulation are not obtained with evaporators to the extent possible with surface condensers, where the circulation of the cooling water is positively controlled by a pump or other means.

5 With submerged tube evaporators, the velocity of circulation can, however, be considerably increased by careful attention to details such as proportions of tubes and the use of circulation tubes, or downtakes. Fig. 4, one of the experimental evaporators used in the experiments, shows such a circulation tube at the center. The boiling liquid ascends through the small tubes and descends through the downtake tube, due to the fact that there is a greater amount of heat transmission per unit of carrying capacity through the small tubes than in the larger circulation tube.

6 *Distribution and Velocity of the Heating Steam.* Of the devices used in commercial evaporators for effecting even steam distribution to the heating surface may be mentioned the annular steam belt surrounding the tubular cluster, with slots through which steam passes radially inward. This has been used very generally with vertical submerged tube evaporators.

7 The vertical submerged tube (standard) evaporator with steam supplied through an annular belt offers little opportunity for securing high steam velocity; in fact, the average steam velocity is very low in this type. One of the evaporators experimented with, shown in Fig. 7, is opposite in principle to the belt type. It was designed to secure high velocity at the expense, however, of considerable friction, instead of low velocity and little friction as in the belt type. The steam tube evaporator gives opportunity for controlling steam velocities within certain limits by proportioning the tubes, a long tube of small diameter giving a greater velocity than a shorter tube of larger diameter.

8 *Presence of Incondensable Gases in the Steam Compartment.* The presence of air or other incondensable gases not only reduces the coefficient of heat transmission because of their resistance to heat conduction, but according to Dalton's law of mixed vapors, produces a temperature in the steam compartment lower than that corresponding to the vacuum shown by the gage and so decreases the temperature fall.

9 Most evaporators are provided with means for removing the

incondensable gases, though in many of them this is done more or less ineffectively because under the agitated conditions incident to the rapid inrush of steam there can be but little segregation. The removal of air must therefore be at the expense of much steam along with it. Incondensable gases are likely to collect in dead spaces which makes the matter of steam distribution of added importance.

10 Fig. 7 illustrates a special device applied to vertical liquid tube evaporators, one object of which is to effect a more efficient removal of the incondensable gases. As the steam passes toward the center of the steam compartment it condenses and gradually becomes richer in air, thus affording a means of separating air from steam, the former being drawn off from the center.

11 Fig. 6 is a steam tube evaporator especially designed to remove incondensable gases effectively. In this case the gases are removed from each steam tube, which is closed at the top, by means of a ⅛-in. pipe. One type of film steam tube evaporator with horizontal tubes vents the gases directly to the vapor space of the boiling liquid through very small holes in the closed end of the tubes.

12 *Hydrostatic Head of the Liquid upon the Heating Surface.* Hydrostatic head of juice, that is, deep submergence of the heating surface, reduces heat transmission and capacity by decreasing the temperature fall for a given vapor pressure difference. The added pressure due to hydrostatic head increases the average temperature of the boiling liquid, and this in turn decreases the temperature fall. For example, assume the steam pressure in the calandria to be 20 lb. absolute and the pressure of the vapor above the boiling liquid 12 lb. absolute, corresponding to temperatures of 228 deg. and 202 deg. respectively. If the evaporator were of the film type, the actual temperature fall would be 26 deg. If it were of the submerged tube type like that of Fig. 5, with the juice level say 48 in. above the lower tube plate then the total pressure of boiling would be equal to the vapor pressure plus the average static liquid pressure. The latter is equal to $\frac{24}{12} \times 0.43 = 0.86$ and the total pressure to $12 + 0.86 = 12.86$ lb. per sq. in., corresponding to a temperature of 205 deg. in which case the temperature fall would be 228 deg. — 205 deg. = 23 deg. instead of 26 deg., as in a film evaporator.

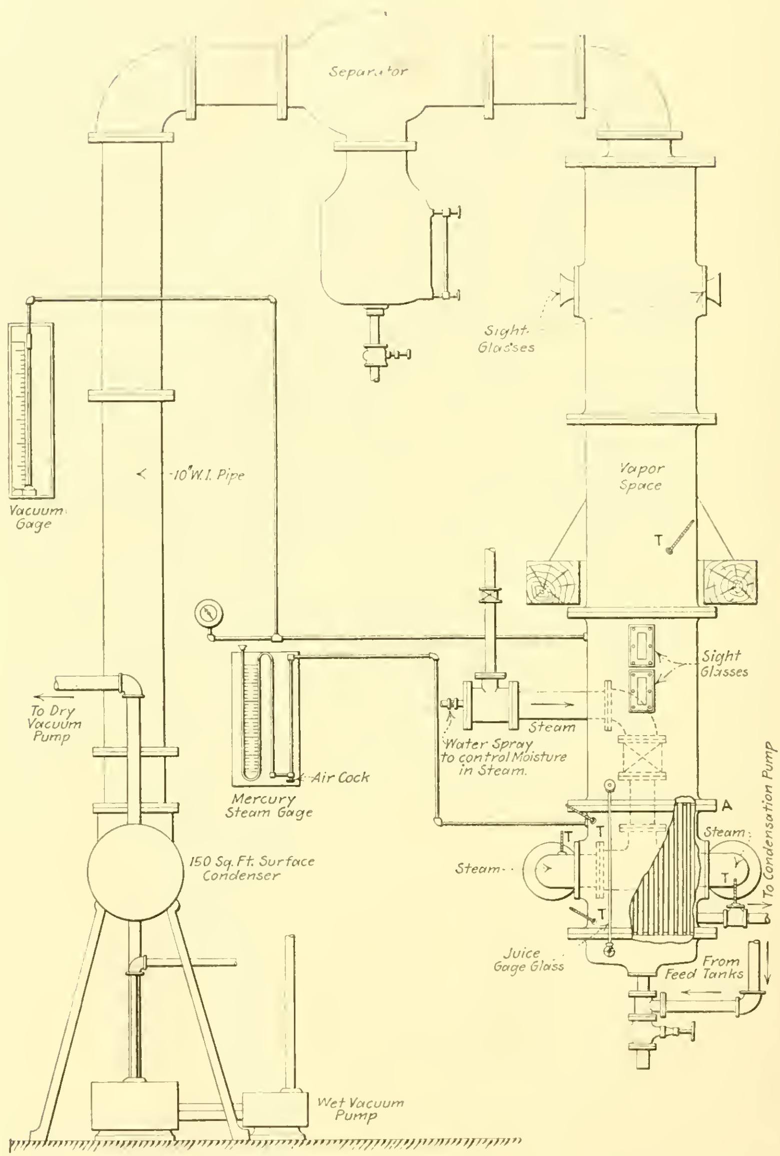


Fig. 1 General Arrangement of Experimental Vacuum Evaporator

A similar calculation will show that the lower the absolute pressure of boiling, the greater the loss in temperature fall with a given depth of submergence, and this means that the loss will be greatest in the last body of a multiple evaporator.

13 *Presence of Condensed Steam upon the Heating Surface.* As with all steam heating apparatus it is important that all condensed steam be removed as it is formed. If allowed to collect

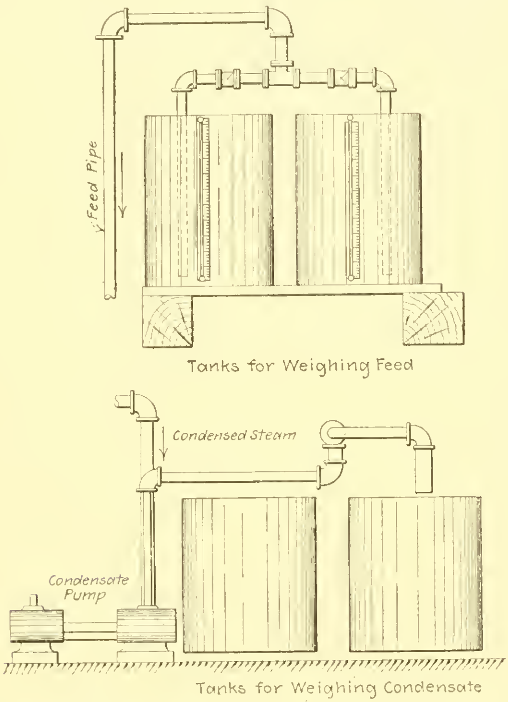


Fig. 2 Weighing Tanks for Experimental Apparatus

in the heating compartment the heating surface thus submerged is made less effective since the transmission from liquid to liquid is less than from steam to liquid. In evaporators with long vertical tubes the condensed steam must run down the entire length of the tubes, and this doubtless reduces the heat transmission. With horizontal steam tubes, the water is swept out of the tubes by the current of steam.

14 *Density of the Liquid being Concentrated.* The density of the liquid being concentrated affects heat transmission in that

the temperature of boiling is increased above that corresponding to the pressure and this results in decreased temperature fall. The coefficient of heat transmission may also be decreased in some cases, though this is a matter of some doubt. The effect of density in this respect is naturally greatest in the later bodies

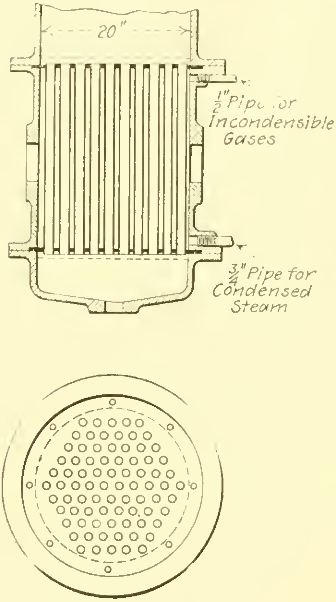


Fig. 3

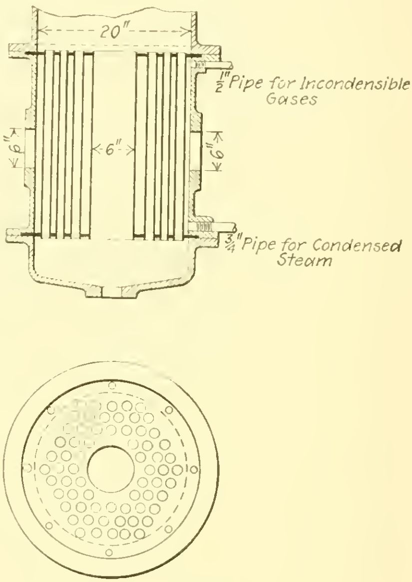


Fig. 4

Fig. 3 80 Copper Tubes 1⅜ In. by 24 In. by 18 Birmingham Wire Gage
Fig. 4 66 Copper Tubes 1⅜ In. by 24 In. by 18 Birmingham Wire Gage.
6 In. Downtake. Tube Plates $\frac{3}{16}$ In. Copper

where the absolute pressure is least and where the density is greatest.

15 *Cleanliness of the Heating Tubes.* The effect of the fouling of heating tubes upon heat transmission is too well known to be remarked. The collection of solid matter upon the heating surface depends mainly upon the nature of the liquid and the velocity of circulation. With sugar juices it is generally necessary to stop the evaporation every one or two weeks to clean the tubes. This may be done by boiling out with caustic soda followed by hydrochloric acid. If exhaust steam is used for heating, there is likely to be some fouling due to the lubricating oil contained, especially if cheap oils, which saponify under the action of heat, are used.

DESCRIPTION OF APPARATUS

16 As it is very difficult to control conditions in the different bodies of a multiple evaporator, it was decided to use an evaporator with a single body so constructed that the conditions existing in any of the bodies of a multiple evaporator could be reproduced. With this in view the apparatus was so designed that it was possible to change the type of heating compartment and to control at will the pressure of the heating steam, the vacuum under which boiling takes place, the quality of the steam, the amount of air in the heating steam, and the density of the liquid.

17 Figs. 1 and 2 show the general arrangement of the plant used in all of the tests. The surface condenser contains 150 sq. ft. of cooling surface, whereas the heating surface in the evaporator itself varied from 50 sq. ft. in the smallest calandria tested up to 86 sq. ft. in the largest. It will be noted that the body of the evaporator is supported above the calandria so that the calandria can be removed and another one bolted on conveniently. Fig. 1 shows the calandria of Fig. 3 bolted to the body at *A*. In changing from one calandria to another this joint had to be broken.

18 Figs. 3 to 7 inclusive show the different types of calandria tested. The calandria shown in Fig. 4 is like that of Fig. 3 except that there is a 6-in. circulation tube or downtake at the center. Fig. 5 shows another calandria with tubes 2 in. in diameter and 48 in. long without a downtake.

19 Fig. 6 shows an evaporator of the steam tube type with special arrangements for removing the incondensable gases. There are two thick tube plates, one above the other, both of cast iron. The heating tubes which are 2 in. in diameter and 54 in. long are expanded into the upper tube plate. These tubes are closed at the top and are open at the bottom. Into the bottom tube plate $\frac{1}{8}$-in. tubes are screwed. These small tubes are open at both ends and are placed inside of the heating tubes, reaching nearly to the top of the latter. The space below the lower tube plate is connected to the vapor space of the succeeding body in an evaporator of commercial size. Steam passes up into the heating tubes in the annular spaces surrounding the gas tubes, the incondensable gases being driven towards the top from whence they are removed by the small gas tubes, each heating tube having

its own individual incondensable gas remover. The lower tube plate is made saucer shape so that the condensed steam drains to the center from where it is removed in the usual manner.

20 Fig. 7 shows a calandria similar to Figs. 3 and 4 with tubes 1¾ in. in diameter and 24 in. long. It differs from them.

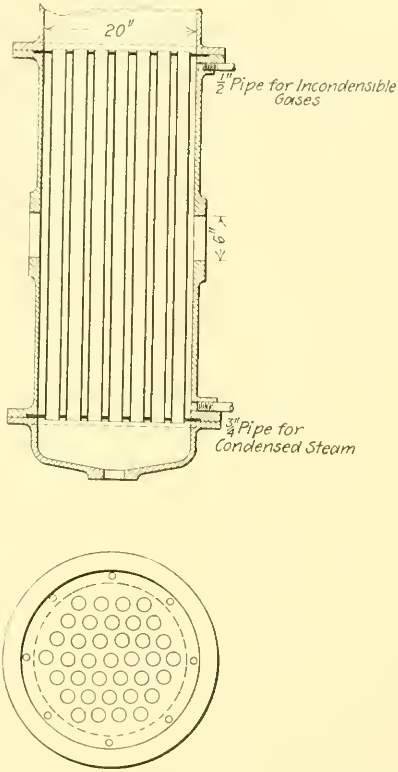


Fig. 5 37 Copper Tubes 2 In. by 48 In. by 18 Birmingham Wire Gage Tube Plates $\frac{3}{16}$ In. Copper

however, in the manner of distributing the steam to the heating tubes, and in the manner of removing the incondensable gases, the steam being supplied through four openings, one above the other, thus giving better distribution vertically. Between the two tube plates a vertical baffle plate is placed so as to guide the steam along a circuitous path to the 3-in. downtake at the center. This baffle plate is so placed that the passage for the steam is gradually reduced in cross-section in order to keep the steam velocity

as high as possible, overcoming to an extent, the tendency to decrease the velocity due to condensation. The incondensable gases are drawn off by means of a small perforated pipe through the

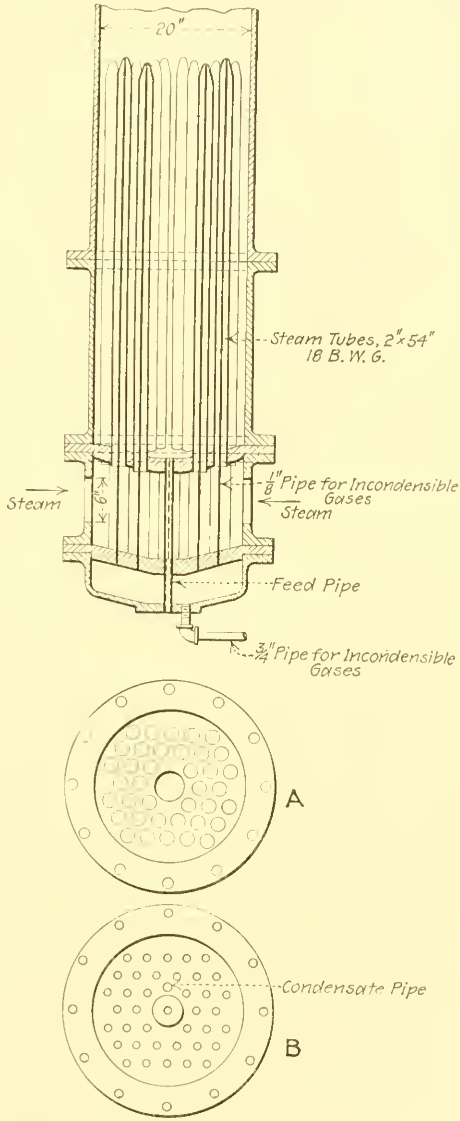


FIG. 6 38 COPPER HEATING TUBES 2 IN. BY 54 IN. BY 18 BIRMINGHAM WIRE GAGE. TOTAL HEATING SURFACE 86.21 SQ. FT.

top tube plate and reaching nearly to the bottom tube plate. The object of this design is to obtain high steam velocity among the heating tubes and effective separation of incondensable gases from steam.

21 The tanks for weighing the condensed steam, or "con-

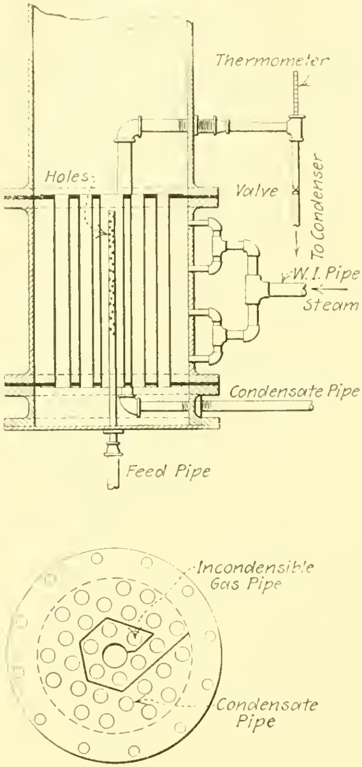


Fig. 7 30 Copper Heating Tubes $1\frac{3}{4}$ In. by 24 In. by 18 Birmingham Wire Gage. Total Heating Surface 29 Sq. Ft.

densate," were used in only a few of the tests in which it was attempted to determine the radiation loss from the surface of the evaporator. The steam used in the evaporator was taken from the power house boiler at a pressure of about 80 lb. gage, the desired pressure in the tube belt being obtained by throttling at the valve.

22 The steam pipe in all of the calandrias except that of Fig. 7 was 6 in. in diameter at the entrance to the tube section and

made to enter at two points. In this way the steam was well distributed. The steam being expanded in some cases from 80 lb. down to less than atmospheric pressure, there was considerable superheat. In order to get steam of varying quality provision was made for spraying water into the steam between the throttling valve and the calandria.

23 In commercial evaporators it is customary to remove the concentrated liquor from the last body by means of a pump. In the experimental outfit a slightly different arrangement was used. In starting a test, sugar juice of the desired density and quantity was placed in the evaporator and as the evaporation progressed water was supplied in such quantities as would keep a constant level in the juice compartment, as shown by the juice gage glass. In this manner conditions sufficiently near those in actual evaporators were obtained with considerably less complexity of apparatus. After being weighed in the calibrated barrels, the water was fed by gravity aided by the vacuum in which the boiling was usually carried on, a valve in the feed pipe being used to regulate it.

24 That part of the evaporator above the top tube plate, which will be designated as vapor space, was 10 ft. high in all of the calandrias tested except that of Fig. 6 in which it was about 8 ft. This liberal height was provided in order to prevent, as far as possible, the carrying over of liquid in the vapors leaving the boiling surface. The separator shown was originally designed to be used as an oil separator, but was here used to catch any liquid entering the vapor pipe.

25 Thermometers were placed as shown in Fig. 1 to measure the temperatures in the steam pipe, the vapor space, the bottom of the steam compartment, the top of the steam compartment, the entering juice or water, the condensed steam and the room. This applies in its entirety to the apparatus when used with the tube sections shown in Figs. 3, 4 and 5. The thermometers were placed somewhat differently for the other tube sections. The mercury manometer connected to the steam compartment could be used with pressure either above or below the atmosphere and was arranged so that the water could be kept out of the mercury column when operating with pressure. With low vacua the wet vacuum pump was sufficient, but with higher vacua, that is, 24 in. or more, it was necessary to use the dry vacuum pump. A ma-

jority of the tests was made with water as the liquid to be boiled, the balance being made with sugar solutions produced by mixing white sugar with water in such proportions as would give desired densities. Liquor made in this manner was clean and pure and gave practically no fouling of the heating tubes. All tests were made with practically clean heating tubes.

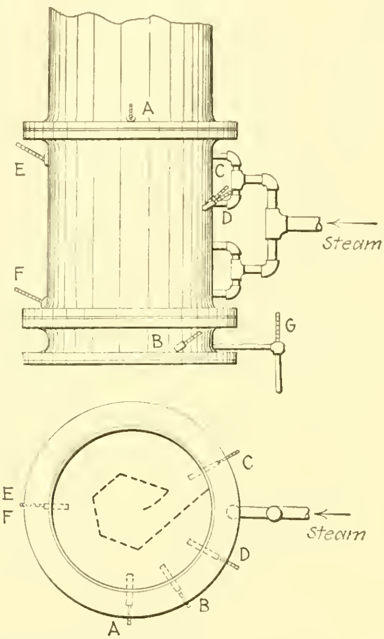


Fig. 8 Diagram showing Location of Thermometers Calandria E

METHOD OF MAKING A TEST

26 In starting a test the wet vacuum pump was first started and a charge of juice drawn in. The condensate pump was then started and steam turned on to warm the apparatus. After the desired conditions as regards steam pressure, vacuum, height of boiling, etc., were obtained the apparatus was operated for some time before the test was started. The duration of the tests varied from 20 to 60 minutes, depending upon conditions. Each test started with the juice level indicated by a string around the juice gage glass and the test ended with the same level. If the boiling was not very rapid and violent the level, as shown by the gage

glass, could be read with sufficient accuracy to enable short tests to be run. When there was more rapid boiling tests of longer duration became necessary.

27 Readings of the instruments were taken every 5 minutes throughout the tests.

EFFECT OF HYDROSTATIC HEAD

28 Tests were made on calandrias A, C, D and E in order to secure data on the effect of hydrostatic head. Four series of

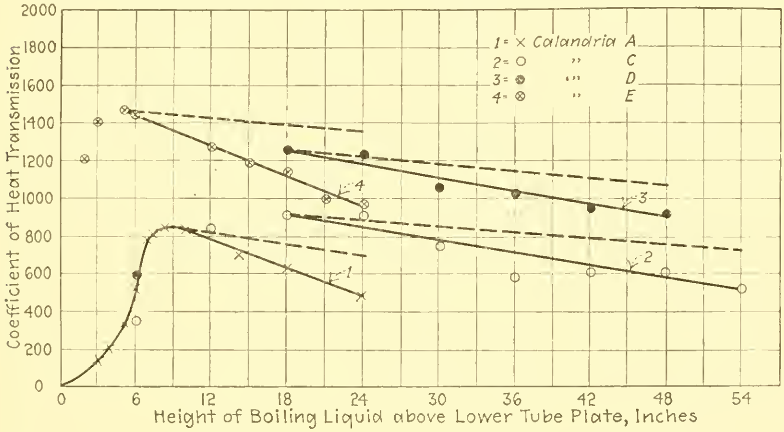


FIG. 9 CURVES SHOWING EFFECT OF HYDROSTATIC HEAD UPON HEAT TRANSMISSION. FULL LINES PLOTTED FROM TEST; BROKEN LINES DRAWN ACCORDING TO CALCULATIONS BASED UPON THEORETICAL LOSS OF TEMPERATURE FALL DUE TO HYDROSTATIC HEAD

tests were run under practically the same conditions of steam and boiling pressures. The height of boiling was varied in each series and other conditions kept constant, or as nearly so as possible. Water was used for boiling in these tests. The results are given in Table 2 of the appendix and are plotted in Fig. 9 herewith.

29 The general procedure in each of these series was to start with very low heads, a test being run for each head and each succeeding test being made with increased head until the desired maximum was reached. At very low heads only the lower portions of the tubes were kept wet by the boiling water, hence more or less of the heating surface was ineffective, the maximum evaporation being obtained with the head at which the ebullition

was sufficient to project the boiling water just to the tops of the tubes. Further increase of head showed a decrease in the rate of evaporation and in the coefficient of heat transmission.

30 The left-hand end of each of the curves plotted in Fig. 9 represents as nearly as can be determined this maximum evaporation. Points obtained with lower heads than this are plotted without drawing curves through them with the exception of Curve 1. The broken lines represent the theoretical decrease in heat transmission due to increase in head, determined as described in Par. 12. It will be noted that the actual curves drop below the theoretical. Just why this is so cannot be determined with certainty, although it may be due to a decrease in the velocity of liquid circulation as the head is increased.

31 Curves 1 and 4, Fig. 9, were both obtained from tests on calandrias with tubes 24 in. long. It will be noted that these two curves are practically parallel. Curve 2 was plotted from tests upon a liquid tube apparatus with tubes 48 in. long, while Curve 3 was plotted from tests upon a calandria having steam tubes 54 in. long. It will be noted that these two curves are also practically parallel to each other. It would thus seem that with tubes having the same length the rate of decrease in evaporation due to hydrostatic head is practically constant. It will be noted further that the curves for the 24-in. tubes are much steeper than those for the longer tubes, showing that the effect of hydrostatic head is greater with short tubes than with longer ones. This is also difficult to explain, although circulation doubtless has something to do with it.

EFFECT OF TEMPERATURE LEVEL

32 The total temperature fall in a multiple effect may be increased by increasing the temperature, or what is the same thing, increasing the pressure of the steam supplied to the first body, or by decreasing the pressure and temperature in the vapor space of the last body. It is evident that increasing the temperature fall, and therefore the capacity, by the first method results in increasing the average temperature in the heating compartments and that the second method results in decreasing it.

33 The relative advantages of high steam pressure in the first body as compared with high vacuum in the last body in obtaining increased heat transmission has been a matter of some question by many. Then, too, the reason for the inequality of temperature

fall in the different bodies of a multiple effect, the greatest fall being always in the last body where the temperature level is lowest, is not definitely known, although it has been thought that the lowest steam density in the last body might be partly responsible.

34 In order to get data that would aid in settling these points a large number of tests were made which are given in Table 3. These tests consist of five series B-1 to B-5 inclusive, each series being made upon a different calandria, but in which the temperature level was varied in practically the same manner, all other conditions in each series being maintained as nearly constant as was possible. The limits of temperature in calandria, although varying somewhat in the different series, approximate those with which multiple effects are operated in practice.

35 The relations between temperature of steam in calandria and coefficient of heat transmission are shown graphically in the curves of Fig. 10. The downward trend of the curves in the low temperature regions gives unmistakable evidence that the lower the temperature level the lower the coefficient of heat transmission, other things being equal. It is most likely that this is due to the lower density of the steam average. Fig. 11 gives an average of the five curves of Fig. 10, but with steam densities instead of temperatures as abscissas. Some of the falling off in capacity at the low pressures may be due to air in the steam. There would naturally be more leakage as the vacuum increased as well as a greater proportion of air to steam. All of the tests were made, however, with tight joints and with the observed temperatures of steam in calandria indicating no partial air pressure. The variation in height of the curves in Fig. 10 is due to various reasons which will be discussed later.

EFFECT OF INCONDENSABLE GASES ON HEAT TRANSMISSION

36 For the purpose of studying the influence of incondensable gases a series of tests was made on calandria A, Fig. 3. The amount of air present in the heating steam was regulated by varying the speed of the condensate pump and by admitting air into the steam compartment through a pet cock shown in Fig. 1. The quantity of air present was determined by the temperature method. Through actual observation of the temperatures in the steam compartment the partial steam pressure was obtained and this subtracted from the gage pressure gave the partial pressure

due to air. The location of the thermometers used for measuring the temperatures in the steam compartment are shown in Fig. 1, two thermometers being used, one near the bottom and one near the top, both of which were about 45 deg. from the left steam pipe entrance. Thermometer wells containing mercury and extending about 2 in. into the steam space were used. The average reading of these two thermometers was assumed to be the temperature in the steam compartment.

37 The results of these tests are given in Table 4 of the ap-

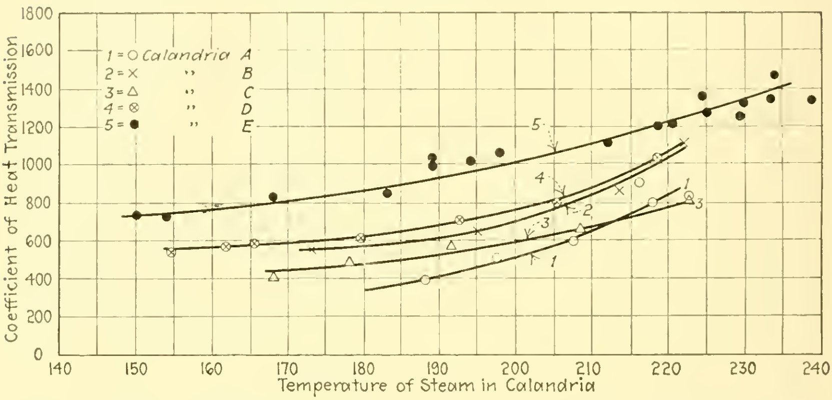


FIG. 10 CURVES SHOWING EFFECT OF TEMPERATURE LEVEL UPON HEAT TRANSMISSION IN FIVE DIFFERENT CALANDRIAS

pendix. Fig. 12 shows the results graphically, $\frac{P_s}{P_t}$ being the ratio of the partial steam pressure to the observed gage pressure. In the equation for the curve

$$U = \left(\frac{P_s}{P_t}\right)^n$$

the exponent n has a value of nearly 3, showing only a slightly greater decrease of the coefficient due to air than in the tests by George A. Orrok[1] on the effect of air in surface condensation in which the value of 2 was given to n. The absolute pressure in the evaporator tests was about 16.5 in. of mercury, whereas in the Orrok tests it was only about 2 in. These evaporator tests differed also from the condenser tests referred to as regards hy-

[1] Air in Surface Condensation, Geo. A. Orrok, Trans. Am. Soc. M. E., vol. 34, p. 713.

drostatic head and the range of the values of the coefficient of heat transmission. In the Orrok tests the maximum coefficient was only slightly above 300 while in the evaporator tests it was above 500. This latter was probably due to the greater steam density in the evaporator tests.

38 Attention has already been called to the fact that the evaporators shown in Figs. 6 and 7 were designed for the especial purpose of overcoming the bad effects of incondensable gases. While it was practically impossible to determine the amount of air present, for the reason that the temperature existing adjacent to the heating surface could not be measured, the results obtained

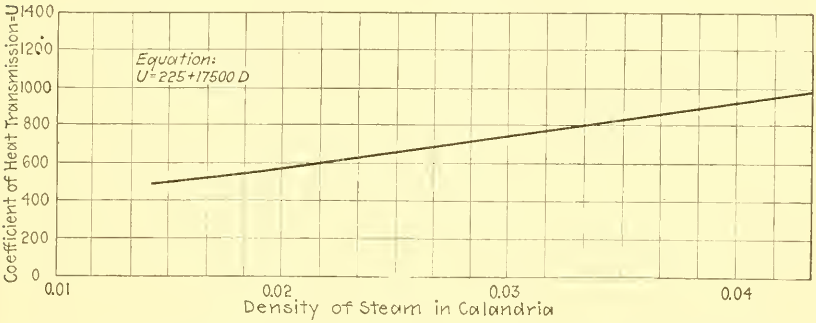


Fig. 11 Curve showing Variation in Heat Transmission with Varying Densities of Heating Steam

with these two arrangements, show considerable improvement in heat transmission over those obtained from the others. This is shown roughly in Fig. 9 by the relative height of the Curves 1 and 4, also Curves 2 and 3. The increase is doubtless due mainly to the more effective separation of air from the steam and to its prompt removal from the heating compartment. The curves shown in Figs. 10 and 15 also show the increased heat transmission in these two calandrias.

39 It will be noticed that the steam used in the tests plotted in Fig. 12 was superheated and although the temperatures in the calandria were taken where steam and condensation were in more or less intimate contact the temperatures found may have been slightly above what would have existed if saturated steam had been used. This probably accounts for the fact that the upper end of the curve shows no air, whereas it is reasonable to suppose there was a small amount present. In view of this fact

the position of the curve may be slightly inaccurate and its value comes mainly from its direction. In several tests on calandria D and calandria E large amounts of air were admitted through the pet cock used for admitting air in the series plotted in Fig. 12. In fact, judging from the amount the pet cock was open, more air was admitted than in any of the tests plotted in the series.

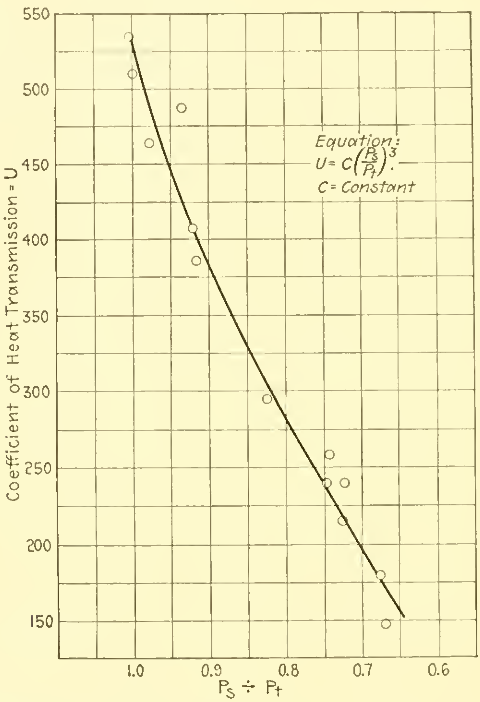


Fig. 12 Curve showing Effect of Air upon Heat Transmission

It was found, however, that such admission of air had little effect in reducing the coefficient of heat transmission.

40 The thermometers inserted in the steam space of calandrias A, B, and C, where temperatures were taken both at the top and bottom, seldom gave equal readings except when there was no air present. This condition occurred only when the observed temperature was equal to or greater than the saturation temperature corresponding to the observed pressure. In the tests on calandria A, the greater temperature was in practically all cases reg-

istered by the thermometer at the top, whereas with calandrias B and C the reverse was the case.

41 In the tests on calandria E, thermometer wells were in-

TABLE 1 VARIED TEMPERATURE CONDITIONS IN CALANDRIA DUE TO PRESENCE OF AIR AND SUPERHEAT

Test Number	Absolute Pressure in Calandria, In. Mercury	Saturation Temperature due to Pressure in Calandria	Temperature, Deg. Fahr., Steam in Calandria				
			at D*	at F*	at E*	at C*	at H*
60	7.6	150.1	150.0	150.4	151.8	151.5	147.3
61	7.99	152.2	151.4	156.4	153.9	154.5	148.8
62	11.12	166.0	165.9	172.3	167.6	170.8	160.3
70	34.75	219.5	221.3	220.7	221.9	219.4	215.2
73	39.84	226.6	229.0	229.6	230.3	230.0	222.6
74	40.55	227.6	230.17	230.8	228.7	231.4	223.7
75	32.10	230.8	234.4	233.0	234.7	232.3	226.1
76	43.57	231.5	235.4	233.8	235.6	234.0	227.0

* See Figs. 7 and 8.

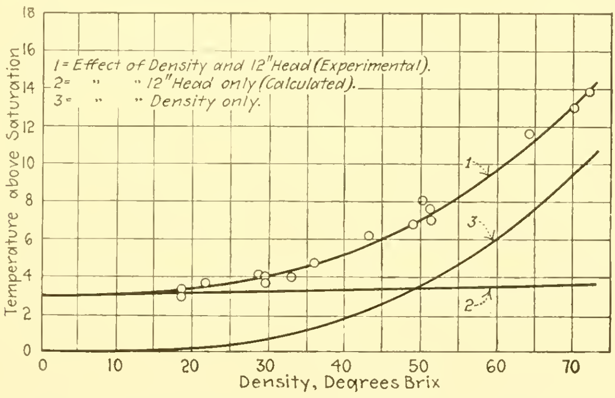


FIG. 13 CURVES SHOWING EFFECT OF DENSITY OF LIQUID UPON BOILING TEMPERATURE

serted at various parts of the calandria as shown in Figs. 7 and 8 for the purpose of observing steam temperatures. Table 1 shows some interesting data selected at random to give an idea of the unstable conditions due to the presence of air and superheat as shown by the variation of temperature at different points and times.

DENSITY OF THE LIQUID

42 The density of liquids may be determined by either of two hydrometers, viz.. Brix or Beaumé. In these tests a Brix hydrometer was used. The following tabulation shows relations which may be of use in grasping the meaning of the data given in Table 5.

Brix	Beaumé	Specific Gravity
0	0	1.0
10	5.7	1.0401
20	11.3	1.0833
30	16.8	1.1296
40	22.3	1.1794
50	27.7	1.2327
60	33.0	1.2899
70	38.1	1.3509

The Brix spindle reads directly the per cent of solids in a solution.

43 Increasing the density of the liquid being boiled decreases the heat transmission by decreasing the temperature fall. The circulation is also affected by the density and this also affects heat transmission. The boiling temperature of solutions increases with the density and in order to get first-hand data on this subject, a series of tests was made upon calandria E, the density of the sugar juice being varied from 18 to 70 Brix and the height of the juice kept at 12 in. The results of these tests are shown in series D-1, Table 5. By subtracting the saturation temperature corresponding to the pressure on the boiling liquid from the observed temperature of the boiling liquid the increase in the boiling temperature due to the combined effect of hydrostatic head and juice density was obtained. Curve 1, Fig. 13, was obtained by plotting these against the corresponding densities. Curve 2 represents the calculated loss in temperature fall due to the 12 in. hydrostatic head for the conditions of the tests. By subtracting the ordinates of Curve 2 from corresponding ones of Curve 1, Curve 3, representing the loss due to density alone, was obtained. The equation of this curve is $y = CD^{3.1}$ in which C = a constant and D = density of liquid, Brix. These tests were very carefully made after many preliminary tests for the purpose of controlling conditions properly and it is believed that the true relation between density and decrease in temperature fall is shown in Curve 3.

44 Another set of tests was made to determine the actual variation in heat transmission as affected by density. The data from these tests is given in series D-2 of Table 5 and shown graphically in Fig. 14.

TYPE OF CALANDRIA

45 The five calandrias tested differ from each other in several fundamental features to which attention has already been called. Most important among these differences of design may be mentioned proportions of tubes, that is, ratio of length to diameter; the use or non-use of downtakes to aid the circulation of the juice and the methods employed for removing incondensable gases. What appears to be more or less conclusive data bearing upon the relative merits of these different designs were obtained in the tests. This is probably brought out best in the hydrostatic tests, Fig. 9, also in the temperature level tests, Fig. 10. Both of these sets of curves, however, show the effects of difference of design only in the rough for the reason that the conditions of operation were not the same in all of the tests. In the case of the temperature level tests there was considerable variation in the hydrostatic head. In order to make these tests more nearly comparable the curves of Fig. 10 are reproduced in Fig. 15

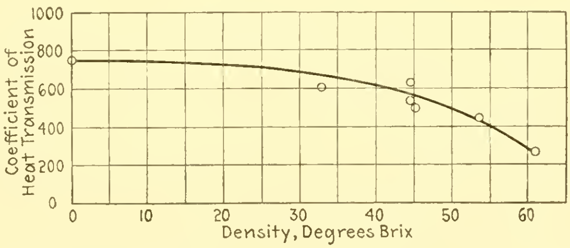


Fig. 14 Curve showing Effect of Density of Liquid upon Heat Transmission

with the necessary corrections for hydrostatic head based upon the curves of Fig. 9. The full line curves are taken without change from Fig. 10. The broken line curves are those corrected for hydrostatic head. The principal conditions during the tests are noted on the plat.

46 Curves 3 and 5 show something as to the effect of varying the proportions of the tubes, the former for tubes 1⅜ in. by 24

in. and the latter for tubes 2 in. by 48 in., some advantage being shown for the long tubes, at least for low temperature levels. The greater heat transmission in the long tubes is probably due to better circulation. The greater the ratio of the length of a tube to its cross-sectional or carrying area, the greater will be the heat transfer per unit of carrying area and this should increase the velocity of circulation.

47 A comparison of Curves 3 and 4 shows a decided advantage for the downtake calandria over that without a downtake. The tests on the downtake calandria were made with a hydrostatic head of 16 in., whereas those on the other were made with

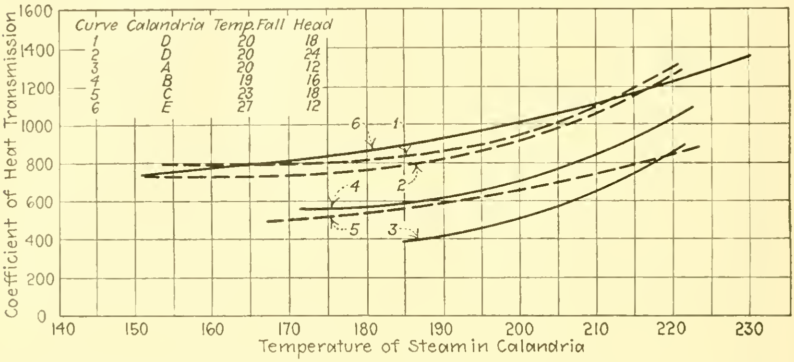


FIG. 15 CURVES COMPARING HEAT TRANSMISSION IN DIFFERENT CALANDRIAS TESTED. FULL LINE CURVES COPIED FROM FIG. 10; BROKEN LINE CURVES SAME AS IN FIG. 10 AFTER CORRECTION FOR HYDROSTATIC HEAD

a 12 in. head. Correction for this difference would slightly increase the advantage shown for the downtake calandria.

48 Curves 1 and 6 show the results of the tests on two types of evaporators designed especially for efficient removal of incondensable gases. Both show coefficients of heat transmission considerably in excess of those obtained with the standard types represented by Curves 3, 4 and 5. Curve 6 for calandria E, the baffle plate calandria with a head of 12 in., is only slightly higher than Curve 1 which represents D, the double tube calandria with an 18 in. head. These relations are also corroborated in a general way by the curves of Fig. 9. While the good results shown for these two calandrias may undoubtedly be attributed mainly to the more efficient separation of incondensable gases from steam and its removal, it is probable that the increased velocity of steam is also partly responsible.

CONCLUSIONS

49 The loss in heat transmission due to hydrostatic head is considerably in excess of the theoretical, and this excess is greater for short tubes than for long tubes. The loss with varying heads, other conditions being equal, varies according to a straight line formula.

50 Other conditions being equal, the lower the "temperature level" the smaller the coefficient of heat transmission, in other words, the lower the temperature and density of the heating steam the smaller the coefficient. The coefficient of heat transmission varies according to the equation

$$U = 2.25 + 17500\,D$$

where D = density of heating steam in pounds per cubic foot.

51 Air or other incondensable gases in the heating steam greatly reduce the heat transmission, even with relatively low vacua. The coefficient of heat transmission varies according to the equation

$$U = C\frac{P_s}{P_t}$$

in which C is a constant, P_s the partial pressure of the steam and P_t the total pressure. The presence of "air pockets" may be conveniently determined by means of thermometers in the steam compartment; good circulation and distribution of steam are important in preventing them.

52 Increasing the density of the boiling liquid causes a loss in heat transmission due to the decrease in temperature fall. As the density is increased the boiling temperature increases according to the equation $y = CD^{3.1}$, in which C = a constant and D = density in deg. Brix. The total loss due to the density of the boiling liquid seems to be in excess of that due to loss of temperature fall. This is probably due to lower velocity of circulation.

53 The great temperature fall required in the last body of a multiple evaporator is due to the combined influence of greater amounts of air, steam of lower density, liquid of higher density, also in many cases, more foul heating surfaces, than in preceding bodies.

54 The downtake or circulation tube was shown to increase heat transmission materially. Long tubes give better results as to heat transmission than short tubes due to better circulation.

55 The tests show that the double tube and the baffle plate calandrias gave greatly increased heat transmission as compared with the standard types tested, and indicate that attention to steam distribution and the removal of incondensable gases is very important.

56 In closing, the author desires to acknowledge the valuable assistance of Messrs. J. A. Gunther and A. J. Isacks, who did most of the testing and calculating. Thanks is due Mr. T. F. Sanborn of New York City who built and furnished the double tube calandria, Fig. 6, and Mr. A. L. Weber of New Orleans who built and furnished the baffle plate calandria, Fig. 7. Some 350 tests have been made on the apparatus described, though this paper includes only those fulfilling required conditions.

APPENDIX

57 In the tables which follow will be found average observed and calculated data taken during the tests. In calandrias A, B and C, temperatures in the steam spaces were obtained by means of thermometers placed both at the bottom and at the top, and the item "observed temperature" given in the tables is the average of the readings from these two temperatures.

58 The temperature fall was found by subtracting the observed temperature in the steam space from the saturation temperature corresponding to the absolute pressure of the heating steam when the observed temperature in the calandria was equal to or greater than the saturation temperature corresponding to the pressure. In case the observed temperature in the calandria was less than the saturation temperature the temperature fall was obtained by subtracting the observed temperature in the vapor space from the observed temperature in the calandria. It was thought best to use saturation temperature in the calandria where superheat was shown, as condensation can take place only at saturation temperatures.

59 The coefficient of heat transmission, that is, "B.t.u. transmitted per square foot of heating surface per degree of temperature fall per hour," was obtained by dividing the B.t.u. transmitted per square foot per hour by the temperature fall. Marks and Davis steam table was used in working up all the tests.

TABLE 2 HEAT TRANSMISSION THROUGH THE TUBES OF A VACUUM EVAPORATOR

To determine the Effect of Hydrostatic Head. Water was used in These Tests

Test Number	Duration of Test, Min.	Absolute Pressures		Temperatures, Deg. Fahr.				Height of Boiling above Lower Tube Plate, In.	Weight of Water Evaporated, Lb.	Temperature Fall, Deg. Fahr.	Water Evaporated per Sq. Ft. Heating Surface, Lb. per Hr.	Coefficient of Heat Transmission
		Vapor Space, In. Mercury	Calandria, In. Mercury	Steam Pipe	Vapor Space, Average	Calandria, Average	Juice Entering					
Series A—1. Calandria A. No Downtake. 56 Sq. Ft. Heating Surface. Tubes 1⅜ In. by 24 In.												
1	30	26.98	33.57	221.5	207.7	219.6	81.0	3.0	37	10.0	1.32	145
2	30	26.45	33.85	221.3	205.0	218.0	82.0	4.0	68	13.0	2.45	204
3	30	26.52	33.89	225.7	206.0	219.3	82.0	5.0	114	12.2	4.07	366
4	30	25.84	33.66	227.0	206.4	218.8	84.0	6.0	149	11.4	5.32	521
5	30	27.24	33.78	230.4	207.6	218.0	82.0	14.0	194	11.0	6.93	692
6	30	26.85	33.63	229.6	206.4	218.0	82.0	18.0	184	11.4	6.57	633
7	30	27.06	34.04	227.5	206.6	218.0	83.0	14.0	150	12.0	5.36	490
8	30	27.08	33.71	229.5	206.6	218.0	82.0	7.0	228	11.4	8.14	784
9	30	27.03	33.51	230.1	207.0	217.4	81.0	10.0	214	10.1	7.64	832
10	20	26.89	33.63	230.5	206.8	217.2	81.0	8.5	148	10.4	7.93	840
11	20	27.07	33.87	229.0	207.0	217.4	81.0	6.5	147	10.4	7.87	813
Series A—2. Calandria C. No Downtake. 75.4 Sq. Ft. Heating Surface. Tubes 2 In. by 48 In.												
12	20	21.80	29.93	231.4	198.6	211.0	81.5	6.0	104	12.4	4.14	365
13	20	22.04	30.01	245.5	197.2	211.65	82.0	12.0	281	14.45	11.18	844
14	20	21.93	29.81	249.4	196.8	211.7	81.0	18.0	310	14.9	12.3	908
15	20	21.96	29.93	248.7	196.8	212.15	81.0	24.0	318	15.21	12.7	912
16	30	21.76	29.90	240.0	196.4	210.8	82.5	30.0	368	14.4	9.76	741
17	30	22.21	30.04	240.8	196.6	210.9	82.8	36.0	284	14.3	7.54	576
18	30	21.74	29.90	236.1	196.2	210.4	81.5	42.0	306	14.2	8.12	605
19	30	21.80	29.88	240.8	195.6	210.85	89.0	48.0	323	15.25	8.57	609
20	30	21.91	29.92	238.6	196.1	211.15	85.0	54.0	270	15.05	7.2	517

TABLE 2—*Continued*

Test Number	Duration of Test, Min.	Absolute Pressures: Vapor Space, In. Mercury	Absolute Pressures: Calandria, In. Mercury	Temperatures, Deg. Fahr.: Steam Pipe	Temperatures, Deg. Fahr.: Vapor Space, Average	Temperatures, Deg. Fahr.: Calandria, Average	Temperatures, Deg. Fahr.: Juice Entering	Height of Boiling above Lower Tube Plate, In.	Weight of Water Evaporated, Lb.	Temperature Fall, Deg. Fahr.	Water Evaporated per Sq. Ft. Heating Surface, Lb. per Hr.	Coefficient of Heat Transmission
Series A—3. Calandria D. 86.21 Sq. Ft. Heating Surface. Tubes 2 In. by 54 In.												
21	23	20.46	29.75	241.7	194.8	219.2	70.0	6.0	300	16.8	11.8	593
22	42	22.05	30.22	228.0	198.2	212.5	70.0	12.0	940	14.15	15.23	1196
23	41	22.25	30.26	254.0	198.1	212.4	70.0	18.0	936	14.3	15.92	1257
24	27	21.45	29.80	257.2	196.1	210.2	70.0	24.0	606	14.1	15.65	1235
25	48	21.95	29.83	232.0	197.0	211.5	71.0	30.0	640	14.5	13.65	1048
26	43	21.56	30.10	255.2	195.8	211.5	71.0	36.0	894	15.7	14.49	1025
27	16	21.54	29.13	247.3	195.1	210.7	70.0	42.0	305	15.55	13.28	943
28	15	21.68	29.38	244.4	196.5	214.3	70.0	48.0	305	15.1	14.15	912
Series A—4. Calandria E. 29 Sq. Ft. Heating Surface. Tubes 1¾ In. by 24 In.												
29	20	21.74	31.71	.....	196.8	216.5	80.0	2.0	193	18.0	19.98	1220
30	20	23.05	33.18	.....	199.0	219.2	78.0	3.0	226	17.9	23.45	1410
31	20	22.87	32.23	.....	198.8	220.2	78.0	5.0	228	16.8	23.55	1468
32	20	22.53	31.61	.....	198.6	219.0	78.0	6.0	214	16.0	22.14	1445
33	20	22.50	39.82	.....	198.7	229.7	79.5	12.0	312	28.0	32.25	1256
34	20	23.65	35.78	.....	199.8	225.0	79.0	15.0	226	21.2	23.4	1192
35	30	22.81	35.62	.....	199.1	225.8	79.5	18.0	337	21.85	23.22	1120
36	30	22.94	35.48	.....	200.4	223.3	78.0	21.0	270	20.1	18.63	993
37	20	22.92	32.52	.....	197.4	220.6	78.0	24.0	166	18.6	17.17	974

TABLE 3 TESTS OF HEAT TRANSMISSION THROUGH THE TUBES OF A VACUUM EVAPORATOR

To determine the Effect of Varying the Temperature Level. Water was used in These Tests

Test Number	Duration of Test, Min.	Absolute Pressures		Temperatures, Deg. Fahr.			Weight of Water Evaporated, Lb.	Temperature Fall, Deg. Fahr.	Water Evaporated per Sq. Ft. Heating Surface, Lb. per Hr.	Coefficient of Heat Transmission
		Vapor Space, In. Mercury	Calandria, In. Mercury	Steam Pipe	Calandria, Average	Juice Entering				
Series B–1 Calandria A. Without Downtake. 56 Sq. Ft. Heating Surface. Head 12 In. Tubes 1⅜ In. by 24 In.										
38	20	23.72	35.93	235.0	222.45	82.0	303	21.27	16.23	835
39	20	22.52	34.09	242.9	218.0	81.0	279	20.5	14.94	800
40	20	21.01	31.97	243.8	215.3	82.0	263	19.42	14.08	913
41	20	18.27	27.59	246.0	207.7	80.0	202	19.7	10.82	601
42	20	14.77	22.64	216.3	197.4	80.5	177	20.0	9.48	517
43	20	12.11	19.14	226.6	188.1	82.0	141	20.45	7.55	399
Series B–2 Calandria B. With Downtake. 53.26 Sq. Ft. Heating Surface. Head 16 In. Tubes 1⅜ In. by 24 In.										
44	60	29.84	35.93	241.2	222.0	83.0	494	9.2	9.28	1108
45	60	21.44	29.93	242.6	213.7	83.0	685	16.4	12.87	857
46	60	14.11	21.46	240.1	195.1	81.0	671	21.4	12.60	647
47	60	8.09	14.02	237.9	172.8	81.0	671	24.3	12.60	558
Series B–3 Calandria C. 75.4 Sq. Ft. Heating Surface. Head 24 In. Tubes 2 In. by 48 In.										
48	20	7.00	12.48	225.3	168.1	81.5	245	26.0	9.75	404
49	20	9.30	14.61	233.6	178.2	80.0	247	21.9	9.85	487
50	20	12.40	19.40	244.0	191.6	80.5	283	21.1	16.22	578
51	20	19.26	27.53	252.3	208.8	81.5	312	16.3	12.46	660
52	20	23.88	36.01	259.2	222.5	82.0	388	21.0	15.44	806

TABLE 3—*Continued*

Test No.	Duration of Test, Min.	Absolute Pressures		Temperatures, Deg. Fahr.			Weight of Water Evaporated, Lb.	Temperature Fall, Deg. Fahr.	Water Evaporated per Sq. Ft. Heating Surface, Lb. per Hr.	Coefficient of Heat Transmission
		Vapor Space, In. Mercury	Calandria, In. Mercury	Steam Pipe	Calandria, Average	Juice Entering				
Series B—4 Calandria D. 86.21 Sq. Ft. Heating Surface. Head 36 In. Tubes 2 In. by 54 In.										
53	25	22.14	33.72	243.9	218.5	76.1	678	20.0	18.9	1029
54	20	17.27	26.25	245.0	205.3	76.1	428	20.15	14.85	797
55	20	12.94	19.8	229.2	192.4	76.1	395	19.8	13.74	700
56	20	9.45	14.92	230.8	179.7	76.1	225	20.1	11.65	628
57	30	6.25	10.81	239.1	165.5	73.5	551	23.3	12.84	594
58	30	5.64	9.94	236.4	161.7	73.5	545	21.25	12.65	583
59	20	5.30	8.38	229.4	154.8	76.0	273	19.4	9.5	527
Series B—5 Calandria E. 29.0 Sq. Ft. Heating Surface. Head 12 In. Tubes 1¾ In. by 24 In.										
60	30	4.1	7.6	.....	150.9	79.0	224	22.44	15.45	738
61	30	4.11	7.99	.....	154.05	79.0	243	24.60	16.74	725
62	30	6.22	11.12	.....	169.15	79.0	261	23.20	18.05	830
63	25	8.28	15.05	.....	181.6	79.0	250	25.7	20.70	857
64	25	8.04	15.84	.....	189.0	77.5	353	28.75	29.27	1045
65	30	8.68	16.66	.....	189.4	77.0	390	28.60	26.89	992
66	30	9.67	18.62	.....	194.1	77.0	409	29.60	28.20	1014
67	25	10.46	20.66	.....	196.6	79.0	363	30.5	30.5	1056
68	20	13.57	27.48	.....	212.2	78.0	327	32.28	33.8	1110
69	25	19.28	32.27	.....	219.2	77.5	451	24.80	27.6	1202
70	30	23.59	34.75	.....	220.8	80.0	300	18.65	20.7	1215
71	20	23.46	35.25	.....	224.4	79.0	255	20.40	26.2	1358
72	25	20.78	35.43	.....	225.0	77.5	387	26.5	31.3	1270
73	20	22.50	39.84	.....	229.7	79.5	312	28.0	32.25	1256
74	30	22.46	40.55	.....	230.28	80.0	511	29.15	35.27	1318
75	30	23.01	43.10	.....	233.6	79.0	545	30.8	37.6	1340
76	20	23.30	43.57	.....	234.7	79.0	415	31.7	43.0	1488
77	20	22.32	47.65	.....	238.3	78.0	670	38.2	46.25	1330

TABLE 4 TESTS OF HEAT TRANSMISSION THROUGH THE TUBES OF A VACUUM EVAPORATOR

TO DETERMINE THE EFFECT OF AIR IN THE HEATING STEAM. WATER USED IN THESE TESTS

SERIES C

CALANDRIA A. NO DOWNTAKE. 56 SQ. FT. HEATING SURFACE. HEAD 12 IN.

Test Number	Duration of Test, Min.	Absolute Pressure: Vapor Space, In. Mercury	Absolute Pressure: Calandria, In. Mercury	Temperature, Deg. Fahr.: Saturation Due to Pressure in Calandria	Temperature, Deg. Fahr.: Steam Pipe	Temperature, Deg. Fahr.: Vapor Space	Temperature, Deg. Fahr.: Calandria, Average	Temperature, Deg. Fahr.: Juice Entering	Weight of Water Evaporated, Lb.	Temperature Fall, Deg. Fahr.	Temperature above or below Saturation in Calandria	Water Evaporated per Sq. Ft., Lb. per Hr.	Coefficient of Heat Transmission	$\frac{p_s}{p_t}$
78	20	8.06	17.64	186.5	244.0	151.8	186.6	80.0	357	34.8	0.1	19.1	594	1.0
79	20	7.94	17.61	186.4	242.6	149.0	186.4	80.0	345	37.4	0.0	18.5	533	1.0
80	20	7.91	17.51	186.2	238.5	151.0	186.0	80.0	311	35.0	− 0.2	16.7	510	0.997
81	20	8.08	17.56	186.3	236.1	152.2	185.0	80.0	274	32.8	− 1.3	14.7	464	0.973
82	20	8.28	17.57	186.32	230.2	153.4	183.0	81.0	277	29.6	− 3.32	14.85	487	0.931
83	20	8.07	17.64	186.5	231.8	152.3	182.5	80.0	242	30.2	− 4.0	12.96	408	0.916
84	20	9.03	17.62	186.45	234.7	152.2	182.3	80.0	228	30.1	− 4.15	12.2	386	0.913
85	20	8.18	17.61	186.4	227.8	152.0	182.1	84.0	180	30.1	− 4.3	9.64	300	0.909
86	20	8.07	17.68	186.6	225.0	154.0	177.7	81.0	167	23.7	− 8.9	8.95	296	0.822
87	20	7.82	17.57	186.32	226.8	150.3	176.7	80.0	177	26.4	− 9.62	9.49	284	0.811
88	20	8.07	17.62	186.45	218.5	152.4	173.0	81.0	152	20.6	−13.45	8.14	258	0.742
89	20	8.19	17.62	186.45	217.8	153.0	173.1	80.0	139	20.1	−13.35	7.45	241	0.744
90	20	8.06	17.59	186.37	215.6	152.6	171.9	80.0	128	19.9	−14.47	6.86	215	0.724
91	20	7.79	17.68	186.5	211.6	152.0	171.9	81.0	144	19.9	−14.7	7.71	240	0.721
92	20	7.97	17.60	186.4	206.2	152.0	168.9	81.0	107	16.9	−17.5	5.73	179	0.676
93	20	8.04	17.57	186.32	203.7	152.0	168.3	80.0	86	15.8	−18.02	4.61	147	0.668

TABLE 5 BOILING TEMPERATURE OF SUGAR JUICE

To determine the Effect of the Density of the Liquid upon Its Boiling Temperature

Test Number	Absolute Pressure: Vapor Space, In. Mercury	Absolute Pressure: Calandria, In. Mercury	Density Juice, Deg. Brix	Temperature, Deg. Fahr.: Boiling Juice	Temperature, Deg. Fahr.: Boiling Corrected to a Pressure of 5.9 In. Mercury	Temperature, Deg. Fahr.: Corresponding to Pressure of Boiling	Temperature, Deg. Fahr.: Boiling above Saturation
Series D−1 Calandria E. 29 Sq. Ft. Heating Surface. Head 12 In.							
94	22.62	39.70	18.58	199.5	143.4	198.2	3.4
95	8.74	19.71	18.58	157.9	142.9	155.9	2.9
96	9.74	20.47	21.59	163.0	143.7	160.2	3.7
97	10.02	22.25	28.61	164.6	144.1	161.6	4.1
98	14.72	27.03	29.61	180.5	144.0	178.3	4.0
99	13.9	24.89	29.62	177.8	143.7	175.7	3.7
100	7.70	18.75	32.84	154.0	144.0	150.7	4.0
101	6.62	16.49	35.86	149.2	144.8	144.7	4.8
102	28.92	40.50	42.92	214.1	146.2	210.3	6.2
103	4.70	8.80	48.80	138.0	146.8	131.5	6.8
104	4.70	9.20	50.00	139.0	148.1	131.5	8.1
105	3.73	10.60	51.00	130.9	147.7	123.0	7.7
106	29.18	42.35	51.07	215.0	147.1	210.5	7.1
107	16.71	29.21	64.0	193.0	151.6	184.0	11.6
108	4.55	13.2	70.00	143.0	153.05	130.25	13.05
109	4.25	13.13	72.00	141.5	153.85	127.75	13.85

TABLE 6 TESTS OF HEAT TRANSMISSION THROUGH THE TUBES OF A VACUUM EVAPORATOR

To determine the Effect of Varying the Density of the Boiling Liquid upon the Heat Transmission

Test Number	Duration of Test, Min.	Absolute Pressure		Temperature, Deg. Fahr.			Density of Juice, Deg. Brix	Weight of Water Evaporated	Coefficient of Heat Transmission
		Vapor Space, In. Mercury	Calandria, In. Mercury	Vapor Space	Calandria, Average	Juice Entering			
Series D–2 Calandria E. 29 Sq. Ft. Heating Surface. Head 14 In.									
	20	5.06	8.60	134.8	156.9	81.0	0	143	758
	25	4.93	8.74	135.07	156.1	81.0	34.1	143	609
	25	4.85	7.90	135.6	154.6	81.0	45.42	115	632
	20	4.89	8.44	136.2	155.2	81.0	45.42	87	526
	20	4.77	8.27	135.2	156.6	81.0	46.16	82	493
	20	5.00	8.72	137.7	158.0	81.0	54.98	90	441
	30	4.65	9.53	135.1	160.6	81.0	61.86	87	264

FOREIGN REVIEW

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

During the past month the Third International Congress of Refrigeration was held in this country. In an early issue of The Journal will be given an account of the technical sessions, with special reference to problems relating to the liquefaction of air, standardization of definitions, and the problem of heating.

THIS MONTH'S ARTICLES

In this month's issue will be found a statement of the principles on which the Altenkirch resorption refrigerating machine is based, which is of interest because it forms an essential part of a system of heating, adapted for use in large buildings, in which ice or cold is produced as a by-product, and which, as Lord Kelvin proved theoretically more than half a century ago, widens the range of temperatures utilized. A part of the potential energy of the coal is converted into heat through the efficient combination of a steam engine (with the utilization of the exhaust steam), a compressor, degaser and resorber. The system gives *an apparent* efficiency of more than 100 per cent if the number of calories and frigories obtained at the heating and cooling ends of the system be compared with the number of calories put in in the form of coal. While it does not of course contradict the law of the conservation of energy, it should receive attention both because of the increasing demand for refrigeration in the summer, and of its high thermal efficiency and economy.

The attention of designers and users of compressed air machinery is called to the article of Groedel (section Air Machinery) which gives a complete analysis of the operation of a compressed air hammer, and describes a process for testing compressed air tools by which a pressure-volume diagram may be obtained. In the same section will be found a brief article on testing apparatus for artificial respiration, and life-saving apparatus for firemen and mine-rescue stations.

The operation of water pump valves, with particular regard to

large canalization pumps is analyzed in the article of Schoene (section Mechanics) where the author shows that, if properly designed, large valves of comparatively small mass may be used quite successfully. In the same section is to be found an article on the pitch of toothed wheels of different materials. The Diesel engine locomotive, the first thermal locomotive in operation, is described and illustrated. Unfortunately no data as to its actual performance can as yet be reported.

In the section on Steam Engineering tests of the efficiency of boilers fired with blast-furnace and coke-oven gas are reported, important both on account of the scarcity of reliable data as to these kinds of steam generators and because the efficiency established is considerably higher than was often assumed. Data on the heat consumption of gas engines are also given. In the same section are reported data of tests from a publication issued by the manufacturers of a 160-h.p. superheated steam locomobile, showing an actual steam consumption of 11.4 lb. per h.p.-hr. An interesting report of the Association for the Inspection of Boilers in Dortmund, Germany, mining district, is also abstracted, and contains, among other things, data as to burning coal-dust in a tar-oil fired furnace under a fire-tube boiler. It contains also some significant references to surface combustion as likely to bring about a revolution in the entire field of power generation.

Articles on torsional strength, torsion indicators, projected new German patent law, possibilities of helicopters as a solution of the problem of safe flight, etc., are to be found in the various sections.

ABSTRACTS OF ARTICLES

Aeronautics

Wall or Blind Alley? (*Mur ou impasse?* G. Plaisant. *L'Aérophile*, vol. 21, no. 16, p. 364, August 15, 1913. 3 pp., 5 figs. *dg*). The author tries to explain the feeling of disparagement which appears to prevail in French military aviation circles, where officers are killed in practice flights without any apparent gain, and where an opinion appears to have gained ground that the present-day aeroplane has reached the highest state of perfection possible, and that unless some radical changes in construction are made, will always remain unstable and dangerous. The author maintains that such radical changes in design are possible, but that the most promising road at the present time lies in coming back to the idea of a helicopter, i. e., apparatus which possesses a lifting power independent of its speed, and points to the success, very partial of course, of the Breguet helicopter, which he describes and illustrates, as the road to follow.

Air Machinery

Experimental and Theoretical Investigation of Compressed Air Machinery (*Experimentelle und theoretische Untersuchungen an Pressluftwerkzeugen*, E. Groedel. *Werkstattstechnik*, vol. 7, no. 15, p. 462, August 1, 1913. 5 pp., 7 figs. *eA*). The first more or less complete investigation of the processes occurring in compressed air tools belongs to Harm (cp. *The Journal*, April 1913, p. 695), who was able, however, to obtain only the piston path diagram. The author describes a method worked out by him at the Technical High School at Darmstadt, Germany, permitting him to obtain the pressure-volume diagram also.

This testing installation is shown in Fig. 1A and B. The plant (Fig. A) comprises a single-cylinder multistage compressor of 120 cbm (4236 cu. ft.) of air per hour, and of a boiler plant. The compressor working at a normal pressure of 7 atmospheres effective, takes about 14 h.p. which is supplied to it by a belt drive from a 24-h.p. gas engine. The compressed air passes into a reserve tank of 3.6 cbm (127 cu. ft.) capacity, and from there through pressure reducing valves, into measuring tanks. Between the latter and the hammer hose are placed an air meter and a dashpot tank. By means of the pressure reducing valve it is possible to maintain the pressure in K_1 and K_2 constantly at 0.005 atmospheres. A mercury partial pressure manometer is conveniently used for pressure measurements.

The testing stand proper is shown mainly in B. Two iron plates P_1 and P_3 are rigidly connected with a concrete block 0.8 m (say 31.4 in.) high. By means of the bow B the hammer, lying in a boring in P_1, is drawn against P_1, and in so doing, it leans with one of its lower edges against plate P_2. P_2 is free to move, and is kept away from P_3: the snap head die D

passes through P_2; during the tests lead wedges of a special form were placed between it and P_3. For the taking of the piston path diagram. a silver thread 3 mm (0.118 in.) in diameter was appropriately fastened to the piston, led through short drilled holes of the snap head die, and provided with a steel recording apparatus of special construction. Fig. B shows a time-path diagram of a striking compressed air hammer. The wavy line to the right on the drum is a record made by a tuning fork, by means of which the peripheral velocity of the drum may be measured. The pressure was recorded by a somewhat modified Schulz optical indicator.

In Fig. C the time-path diagrams are placed below one another. As only

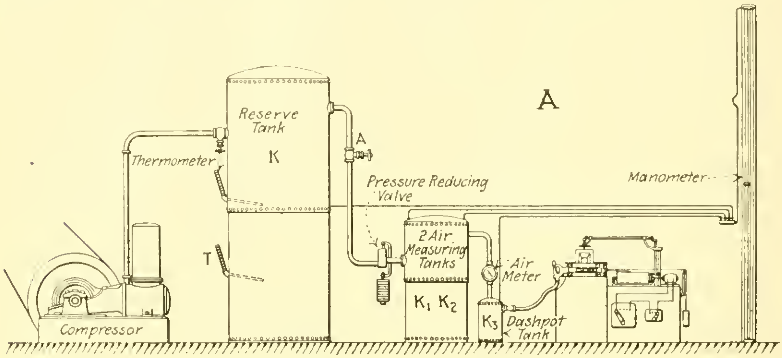


Fig. 1A Plant for Testing Compressed Air Tools

one indicator was available, the striking and the return blows were indicated separately, but the uniformity with which these hammers worked made the juxtaposition of such two observations appear permissible. The piston-path diagrams, as can be seen, nearly coincide. From the time diagrams the pressure-volume diagrams are derived by means of, e. g., plotting the pressure p from the time diagram for the rear side of the piston over the atmospheric line on the right side in the piston position s. The diagram obtained in this way, i. e., point after point, requires, however, some additional drawing. The spring scale of the indicator varies considerably, and from its calibration curve, corrections are obtained, lines r-r, by the use of which the final P-V diagram, drawn to a uniform scale of 1 cm.-1 atmosphere, is obtained.

For the diagram C one of the best hammers obtainable was used. From the position of the ports A, R, U and C, as indicated, it may be seen that the admission line in the diagram for the rear side of the piston is depressed, owing to throttling at entrances down to point 2, and at point 4 escape of air begins, which continues also during the return stroke of the piston, but stops when port A is closed. In the return stroke compression begins at 5, and at 6 the valve opens the admission which continues at a pressure above the working pressure until the beginning of the line of cut-off at the reversal of the stroke. During the striking blow a slight rise of pressure takes place under the piston up to 7, while the

admission lead begins. The piston is then driven back, past 8 to 9, under a fairly uniform pressure and at 9 the exhaust under the piston takes place. The author does not discuss the nature of the oscillations which appear in the diagram, but states that they are of exceptional interest for the determination of the behavior of the air and valves. and will be investigated separately.

Diagram C is used in the following way for the derivation of numerical characteristics of a compressed hammer. The velocity of the piston

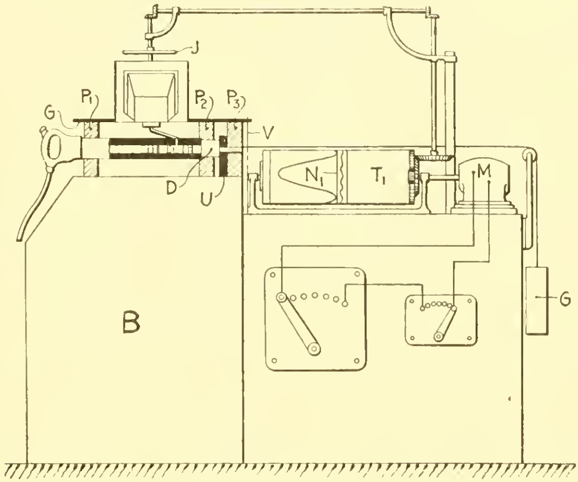


Fig. 1B Testing Stand for Testing Compressed Air Tools

V_e is determined by graphic differentiation by means of a tangent drawn at the end of the stroke curve and is

$$V_e = \frac{ds}{dt} = \frac{0.164}{0.01287} = 12.78 \text{ m/sec.}$$

The weight of the piston being $G = 0.612$ kg., the effective force of blow is

$$A_b = \frac{m}{2} V_e^2 = \frac{0.612}{2 \times 9.81} \times 12.78^2 = 5.1 \text{ mkg.}$$

The duration of blow t_e is determined by measurement (in this case 223 mm) on the drum circumference. or on the diagram sheet flattened out. As the tuning fork curve has the ratio 46.5 mm = 0.01287 sec.

$$t_e = \frac{0.01287 \times 223}{46.5} = 0.0617 \text{ sec.}$$

from which the number of blows per minute n_e is easily determined. Hence the hammer output is

$$L_e = \frac{A_e}{60} \times \frac{n_e}{75} \quad 1.1 \text{ h.p.}$$

The data as to air consumption permit the derivation (it is not stated what process was used by the author) of the thermal efficiency η_t referred to adiabatic expansion of air. and the economic efficiency η_w referred to the compressor work theoretically required. In this case $\eta_t = 0.302$, and $\eta_w = 0.196$

if η_w be calculated on the basis of two-stage adiabatic compression. Practically, however, the power required at the compressor shaft is larger, and if a total efficiency of 75 per cent be assumed in the generation of compressed air, then

$$\eta = \eta_w \times 0.75 = 0.147$$

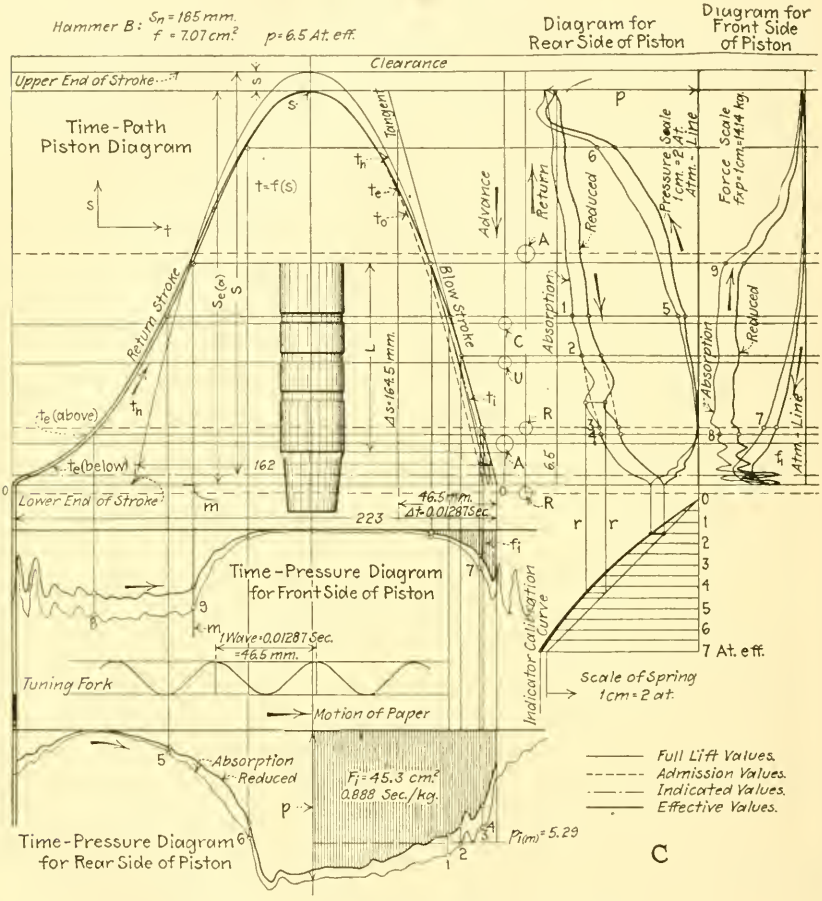


Fig. 1C Diagram for Compressed Air Hammer

which means that the engine driving the compressor feeding a hammer of 1.1 h.p. must deliver

$$\frac{1.1}{0.147} = 7.49 \text{ h.p.}$$

which may be increased still further through presence of untight places and consequent air leaks.

A further basis for comparing hammers of different constructions is suggested by the author in what he calls "degree of utilization" (*Ausnut-*

zungsgrad). An ideal case is assumed of a piston free from friction during the striking and return strokes with no loss of lift, driven by full and constant working pressure; for this case the force of the blow and number of blows are calculated. The striking body follows the laws of uniformly accelerated motion, and the "theoretical duration of blow" of a simple stroke is

$$t = \sqrt{\frac{2S}{b}} = \sqrt{\frac{2Sm}{f.p}}$$

where S is the "constructive" stroke, b acceleration of mass m due to a constantly acting force, while $f \times p$ means piston area times pressure. The "theoretical number of blows per minutes" is $n = \frac{60}{t}$, and the "theoretical force of blow per stroke" $A = f.p.S$. The "theoretical output" is then $L = \frac{An}{60}$ and the "degree of utilization" is the ratio

$$\eta a = \frac{L_e}{L} = \frac{1.1}{3.98} = 0.436$$

The author shows also how to determine the mechanical efficiency of the hammer, and gives tables of numerical data obtained in his tests which cannot be reported here owing to lack of space.

Devices for Testing Apparatus for Artificial Respiration (*Prüfungsvorrichtungen für Sauerstoff-Atmungsgeräte*, Forstmann. *Glückauf*, vol. 49, no. 31, p. 1216, August 2, 1913. 3 pp., 4figs. *d*). Several occasions when life-saving apparatus using artificial respiration have failed to work properly have shown the necessity of some reliable and rapid method of testing them. This applies particularly to the so-called automatic apparatus, i.e., those having an automatically working pressure-reducing valve and injector, which are liable to get out of order even with small amounts of dirt in the working parts. The author describes two special testing devices made by two concerns manufacturing the automatic life-saving apparatus. He states, however, that for rapid tests just previous to using, the special vacuum gage (*Depressionsmesser*) now in use is still the best device in existence. Tests ought to be made, however, for suction and not compression, because in this way the air-tightness of the apparatus may be also tested. Particular attention must be paid to the state which the rubber parts are in. (This applies especially to apparatus used in tropical countries where rubber articles do not last long. Editor.)

Internal Combustion Engines

Concerning the Scavenging Process of Gas Engines (*Über Ausspülverfahren bei Gasmaschinen*, A. Nolte. *Stahl und Eisen*, vol. 33, no. 32, p. 1301, August 7, 1913. 6 pp., 11 figs. *ct*). Discussion of the scavenging process as a means of improving the efficiency of the large gas engine. The author describes briefly the introduction of the scavenging process, and the chief types of engines in which it is used, and cites data of some tests showing the higher efficiency of engines with scavenging as compared with those without.

Mechanics

Tests with Large Annular Valves operated by Laminated Springs for Canalization Pumps, and Contribution to the Dynamics of Valve Motion (*Versuche mit grossen durch Blattfedern geführten Ring ventilen für Kanalisationspumpen, und Beitrage zur Dynamik der Ventil bewegung*, Kurt Schoene. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 32, p. 1246, August 9, 1913. *cA*). The author states that notwithstanding the large amount of experimental work already done (of which a historical sketch is given), the working processes of water pump valves, their opening and especially their closing, are as yet by no means clear. The article is not suitable for full abstracting, and therefore only the conclusions will be reported here. It is not permissible to assume, for the beginning and end of the valve motion, that the clearance velocity is constant: it actually increases, under all circumstances, from zero up to a certain value.

Valve closing, with particular reference to the influence of frictional resistance in the valve guide, and when several valves work in groups. The author states that the closing of the valve after the reversal of stroke has been hitherto treated either under the inadmissible assumption that the velocity of discharge is constant, or in a very general manner. As a matter of fact, however, what happens after the reversal of stroke is of great importance to the proper working of a pump, and the author shows that the closing of a valve (say, suction valve) occurs in the following manner: At the instant of the reversal of stroke the water column above and below the valve is at rest (aside from eddies and motions of oscillatory character), and the water which is still flowing out with considerable velocity along the circumference of the valve, fills the space above the valve which becomes free, owing to the motion of the valve. The velocity of the valve is then gradually decreased owing to the reduction of the spring action, but the partial vacuum increases, since, owing to the seats coming closer together, a greater pressure is necessary for the production of the velocity of discharge. As the displacement of the valve decreases, the influence on the closing process of the displacement of the piston increases. Because the free space above the valve is, to a large part, filled by water driven in by the piston, there is scarcely any room for water flowing over the circumference of the valve, and consequently the velocity of such flow rapidly decreases, and the kinetic energy of the column of water between the valve seats is converted into pressure acting on the valve from above, since, as a further consequence of the decrease of the velocity of discharge, the pressure under the valve decreases also, and a strong acceleration of the valve takes place, lasting down to the closing of the valve.

The above describes what happens normally when the load on the valve is large enough to communicate to it sufficient velocity and when there is no interference from special frictional or other resistances. If these conditions are not satisfied, the valve velocity rapidly decreases, and the time is reached when the piston displacement exceeds the valve displacement. At that instant the direction of clearance velocity is reversed, and water begins to flow in from outside, the pressure above the valve rises, and both the valve motion and the flow of the liquid inward are acceler-

ated. This acceleration and also the valve knock are the stronger the greater the piston velocity.

In all these processes the relations between the piston displacement and the valve displacement are of great importance. It is of advantage if the former is, up to the time of closing, always larger than the latter. The occurrence of particularly unfavorable conditions is especially apt to take place with group valves. If in these valves the guides are not free from friction, a uniform closing is not to be expected and, if out of a large number of valves, a few are kept open, the piston displacement materially exceeds the valve displacement even at high valve velocities, and the water flows violently back through the valves which are late in closing, causing strong knocks. This is the reason why group valves, notwithstanding their moderate mass, have given so little satisfaction, while large and heavy annular valves have proved both more reliable and regular

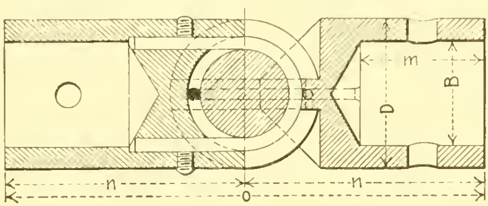


Fig. 2 Ball Socket Joint

in operation. In group valves it is important to see that the closing be as uniform and simultaneous as possible. This is helped by making the guides as frictionless as possible, and selecting large units and the lowest possible number of independent parts.

The tests (full data in the original article) show that a large valve of comparatively small mass may work quite well, if the valve discs be provided with proper laminated springs. By these means valves may be obtained of such great diameters and such long strokes that they may be used in canalization pumps instead of flap valves. Tests made in the laboratories of the Technical High School at Charlottenburg have shown the reliability of annular valves of such unusual dimensions as 300 mm (11.8 in.) average clearance diameter, and 76 mm (say 3 in.) clearance width at 60 or 70 r.p.m.

Ball Socket Joint (*Articulation à rotule*, R. d'Estrel. *Revue Industrielle*, vol. 44, no. 2098/33, p. 454, August 16, 1913. ½ p., 2 figs. *d*). Description of a ball socket joint made by the Ludwig Loewe Company of Germany. In this system (Fig. 2) the ball socket is spherical, and there is no ⊥ shaped break in the section of the ball. While joints of usual construction broke under a static load of 74 kg. (162.8 lb.), this joint resisted up to 110 kg. (232 lb.).

Torsion Dynamometer with Optical Index (*Torsions-Dynamometer mit optischer Absleevorrichtung*, V. Vieweg. *Archiv für Elektrotechnik*, vol. 2, no. 2, p. 49, 1913. 3 pp., 2 figs. *d*). Description of a torsion dynamometer of great precision, with an indexing device constructed in accord-

ance with the Brodhun method (a rotating mirror making an angle of 45 deg. with the axis, is placed at such a distance that the virtual image formed by the nonius and scale falls into the axis of rotation). The Brodhun method has been widely applied in photometry, and with torsion dynamometers gives better results than the formerly used stroboscopic method.

Pitch of Toothed Wheels of Different Materials in Mesh (*Teilung für zusammenarbeitende Zahnräder aus verschiedenem Material*, R. Krell. *Die Fördertechnik*, vol. 6, no. 7, p. 164, July 1913. 2 pp., 4 figs. *tA*). Some engineering handbooks give formulae for the determination of the pitch of teeth o wooden and cast-iron (mainly) wheels in mesh, but a general formula become necessary in view of the variety of materials now used, and high speeds em

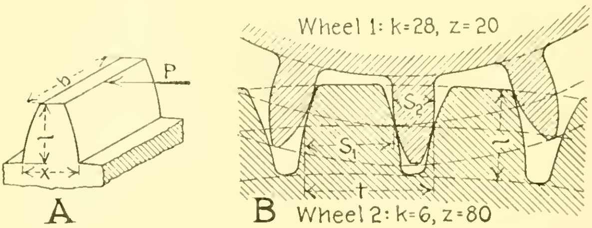


Fig. 3 Wheels of Different Materials in Mesh

ployed. The author gives the following solution of this problem. The general formula for the determination of pitch is (Fig. 3A):

$$P \,.\, l = \frac{1}{6}\, b \,.\, x^2 \,.\, k_b$$

where k_b is the permissible bending stress on the material of the toothed wheel. If the depth of tooth l and thickness of tooth at root x be expressed in terms of pitch t, by stating that $l = \alpha t$, and $x = \beta t$, then

$$P = \frac{1}{6}\frac{\beta^2}{\alpha}\, k_b \,.\, b \,.\, t \,. = k \,.\, b \,.\, t \ldots\ldots\ldots\ldots [1]$$

The coefficient $k = \frac{1}{6}\frac{\beta^2}{\alpha} k_b$ is selected in accordance with the assumption that $1 = 0.7\ t$, and $x \cong 0.5\ t$. The required common pitch for the toothed wheels 1 and 2 (Fig. 3B) is t, the corresponding width b, depth of tooth l. The usual pitch t_1 for the wheel 1 for width b is determined from the equation $P = k_1 \,.\, b \,.\, t_1$, and that for wheel 2 from equation $P = k_2 \,.\, b \,.\, t_2$, while the common pitch is found from the equation

$$t = \frac{t_1 + t_2}{2} \ldots\ldots\ldots\ldots [2]$$

These equations, however, have not yet taken into consideration the fact that in wheel 1 the depth of tooth is somewhat greater than normal ($> 0.7\ t_1$), while in the wheel 2 it is somewhat less than normal ($< 0.7\ t_2$). This affects the coefficients k_1 and k_2 in the expressions for P. From equation [1] it appears that

$k=\frac{m}{a}$, if $m=\frac{1}{6}\beta k_b$, and the unusual depth of tooth is taken care of by multiplying the corresponding coefficient by ζ

$$'k=\frac{m}{a\,.\,\zeta}=\frac{k}{\zeta}$$

Hence $'k_1=k_1\,.\,\frac{1}{\zeta_1}$ and $'k_2=k_2\,.\,\frac{1}{\zeta_2}$

But $1=at=a\,.\,\zeta_1 t_1=a\,.\,\zeta_2 t_2$, and therefore $\zeta_1=\frac{t}{t_1}$, and $\zeta_2=\frac{t}{t_2}$

Hence

$$'k_1=k_1\frac{t}{t_1} \qquad [3]$$

$$'k_2=k_2\frac{t}{t_2} \qquad [4]$$

If now the two equations for P with the new coefficients be solved for t_1 and t_2 respectively, and added, with the substitution of the values of the coeffieients obtained from [3] and [4], b being replaced by $b=\psi t$, equation [2] will assume the following form:

$$t=\frac{1}{2}\left(\sqrt{\frac{P}{\psi\,.\,k_1}}+\sqrt{\frac{P}{\psi\,.\,k_2}}\right) \qquad [5]$$

while through further transformation the following is obtained:

$$P=4\psi t^2\frac{k_1\,.\,k_2}{k_1+k_2+2\sqrt{k_1k_2}} \qquad [6]$$

$$t=\frac{1}{2}\sqrt{\frac{P}{\psi}\cdot\frac{k_1+k_2+2\sqrt{k_1\,.\,k_2}}{k_1\,.\,k_2}} \qquad [7]$$

the widths of the teeth s_1 and s_2, from equation $s=0.5\ t$, may be expressed in terms of t as follows:

$$s_1=t.\ \frac{\sqrt{k_2}}{\sqrt{k_1}+\sqrt{k_2}} \qquad [8]$$

$$s_2=t\ .\ \frac{\sqrt{k_1}}{\sqrt{k_1}+\sqrt{k_2}} \qquad [9]$$

Somewhat simpler equations may be deduced (the author does it) for the case when the unusual depth of tooth may be neglected, and where the bending stresses in the two materials are not very different from one another.

Railroad Engineering

The First Thermal Locomotive (*Die erste Thermo-Lokomotive*. F. Stornenberg. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 34, p. 1325. August 23, 1913. 6 pp., 20 figs. *d*). Description of the first Diesel engine locomotive. It was built for the Thermo-Locomotive Company by Sulzer Brothers in Winterthur (engines and equipment), and A. Borsig in Berlin-Tegel (frames and underframes). After preliminary tests on the line Winterthur-Romanshorn in March 1913, the locomotive was taken under its own power to Berlin, pulling on some of the sections fast freight trains, together with the steam locomotive, and developing

speeds up to 70 km/hr. (43 miles per hour), the velocity generally varying, according to schedule, from 20 to 100 km/hr. (62 miles per hour).

The power plant of the locomotive consists essentially of a driving engine direct connected with the driving axle of the locomotive and an independent auxiliary engine, having one-fifth to one-fourth the power of the driving engine, and serving for the production of compressed air, to help out the main driving engine at starting, on steep grades, etc. In addition, there are inserted between the driving and the auxiliary engines, compressed air tanks, acting as a power reserve, whether the auxiliary engine is stationary or moving. Fig. 4A schematically shows the arrangement of the thermal locomotive: *a* is the engine direct connected to the driving axle of the locomotive *b* (this engine is reversible); *c* is the auxiliary engine, serving to drive the air compressor *d* which in

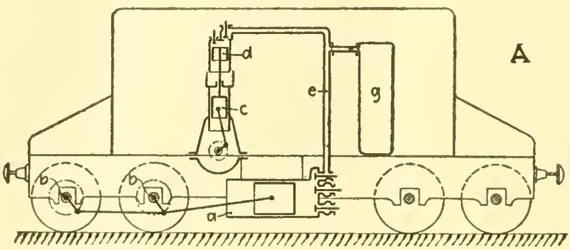


Fig. 4A Schematic Arrangement of Thermal Locomotive

its turn supplies, through piping *e*, compressed air at great pressure to the driving engine *a*. At starting the auxiliary engine *c* is kept going, and supplies compressed air to start the driving engine; it can then receive comparatively large quantities of air which can be increased still further by the compressed air from the reserve tank *g*. On compressed air only, the train (?) will reach a speed of 8 to 10 miles an hour. The engine is then shifted on to fuel and goes on working with its usual regularity. Another arrangement has been patented also, in which the compressed air is supplied partly by the auxiliary and partly by the driving engine.

The general construction of the thermal locomotive is indicated in Fig. 4B. The fast train locomotive is 16.6 m (54.4 ft.) long overall, and weighs in service 95 t (104.5 short tons). The wheel base at the coupled axles is 3600 mm (141 in.), at both bogies 2200 mm (86.5 in.); the distance between bogie pins, center to center, 10,500 mm (345 ft.); the coupled wheels have tread circle diameters equal to 1750 mm (68.7 in.). The driving force is transmitted from a loose shaft to the coupled wheels by coupling rods, having their heads provided with adjustable brasses. The bogies are displaceable sidewise in order to handle freely curves up to 180 mm (590 ft.) radius. The wheels have 1000 mm (3.28 ft.) diameter. The sidewise play of the journal guides is elastically limited by powerful laminated springs acting horizontally. The coupled wheels and the laminated springs are placed under the axles. To secure the greatest possible

damping of vibrations, the suspension links for these bearing springs are themselves in the form of springs, viz., double spiral. The bogies are also on laminated springs, which apply under the axle of the bogie by means of a cradle-shaped support.

The driver's cab extends through the entire length of the locomotive. In the four corners of the carriage body are built tanks, on one end for water, and on the other for both cooling water and fuel. In the roof, over the driving engine is placed the exhaust pipe. Two pumps, driven

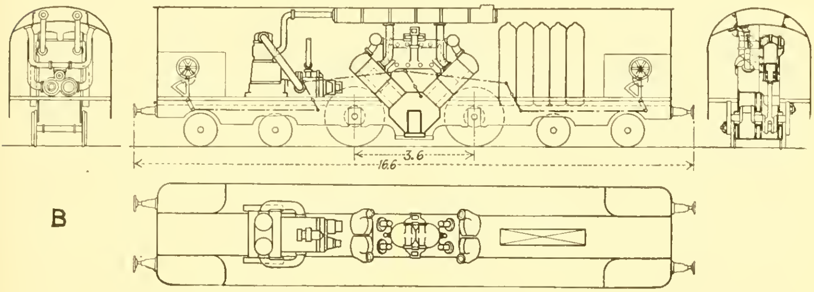


Fig. 4B General Construction of Thermal Locomotive

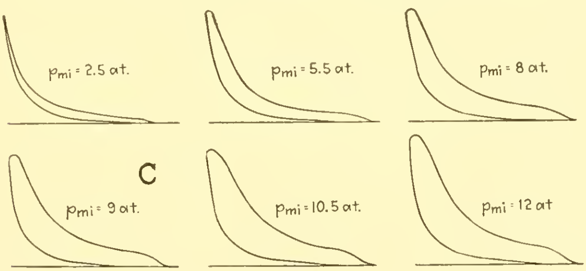


Fig. 4C Indicator Diagrams at Various Pressures

by the driving and the auxiliary engines respectively, provide for the circulation of the cooling water, suction of the water for cooling the piston, and delivery of the fuel from the fuel tank.

The driving engine is a reversible, four-cylinder, single-acting, two-stroke cycle Sulzer engine, with four cylinders arranged in pairs in V, one pair at 90 deg. to the other, and all at 45 deg. to the plane of the rails. Each pair of opposed cylinders lies in the same plane and acts on a common crank pin, the connecting rods being made forked in order to secure the most symmetrical action. The two cranks are placed at 180 deg. and make, when the locomotive runs 100 km/hr. (62 miles per hour) 304 r.p.m. The article describes in detail the very interesting arrangement for the regulation of the fuel valve and compressed air starting valve. The auxiliary engine is a 250-h.p. Diesel Sulzer, two-stroke cycle engine, having two vertical cylinders Fig. 4C reproduces the indicator diagrams

given in the article, at various pressures. No detailed data as to tests are published as yet.

Refrigerating Machinery

Reversible Absorption and Resorption Machines (*Reversible Absorptionsmaschinen und Resorptionsmaschinen*, A. Altenkirch. *Eis-und Kälteindustrie*, vol. 6, no. 2, p. 29, August 1913. 5 pp., 5 figs. *adt*). The author discusses and compares absorption and compression refrigerating machines from the point of view of their thermal (Lorenz cycle) and economic efficiency, and indicates the conditions under which the absorption machine may have a particularly high efficiency: It must approach as far as possible the Lorenz cycle which must be closely followed, not only in the driving engine, but also in the condenser and evaporator; this can be done by effecting the liquefaction of the ammonia vapor, not by a condenser, but by absorbing it in a solution of appropriate concentration. The cold is then produced by degasification (*Entgasung*) of the highly concentrated solution. The machines are called *resorption* machines, and the author describes an older type of such a machine patented by Osenbrück. This has, however, the following imperfect details: The cold required for the precooling of the rich solution is taken from the "degaser" (as the author calls the part where degasification occurs), and therefore no improvement in the output of cold takes place through the application of the counter-current principle. Further, the liquid appears to destroy just the cold at the lowest temperature, i.e., the one most valuable thermodynamically. But if the counter-current principle be applied, then the cold in the warmer part of the absorber may be used for precoolnig the rich solution, as the cold is delivered outward at a lower temperature than when no counter-current is applied.

The same applies to the "resorber," as the absorber is called, which in these machines takes the place of the condenser. The average temperature of the resorber, as compared with that of the surrounding media, rises with the intensification of the counter-current flow of the poor solution previous to its entrance into the resorber, this being done exclusively by the counter-current flow without the expenditure of any outside work whatever. For the same *external temperature* differences as before, the application of the counter-current principle reduces the actual temperature differences between the different reservoirs, and consequently also the consumption of work. Should, however, the resorption machine be driven by an absorption machine and not by a compressor, the reduction of the actual temperature or pressure differences through the application of counter-current flow would result in a still greater overlapping of temperatures, and consequently reduction of heat consumption. This action is still greater owing to the following important fact: According to R. Plank, the output of cold of the degaser rises with the rise of temperature at which degasification occurs. As a rule this cold, obtained at a comparatively high temperature, finds no utilization, but in this case it is used for the precooling of the rich solution, which means also, in addition to increase in the absolute output of cold, an improvement in the operation of the evaporator of the ordinary absorption machine, which when pro-

vided with a condenser, may be considered as only a special case of the resorption machine. As with the absorption machine, here also, by varying the stroke volume, it is entirely possible to extend the degasification and absorption over a more or less wide reach of temperatures. If with plenty of cooling water available, it is desired to make ice, a narrow range of degasification and a wide variation of temperature are employed. Otherwise when it is desired to have the cooling water come out fairly warm, as when it is to be used as warm water, degasification is carried on largely that the poor solution may take up gas in the resorber at a comparatively high temperature.

Steam Engineering

Efficiency of Steam Boilers with Blast-Furnace and Coke-Oven Gas Firing, and Heat Consumption of Gas Engines (*Wirkungsgrad von Dampfkesseln mit Hochofen-und Koksofengas-Heizung und Wärmeverbrauch von Gasmaschinen*, H. Ortmann. *Stahl und Eisen*, vol. 33, no. 34, p. 1397, August 27, 1913. 3 pp. c1). Data of tests of gas-fired boilers.

TABLE 1A TESTS OF A COKE-OVEN GAS-FIRED BOILER (HEATING SURFACE 86QM = 925 SQ. FT.)

Date of Test	Duration		Water Consumption		Average Steam Pressure		Average Gas Pressure		Gas Consumption		Efficiency Per Cent
	Hr.	Min.	Kg.	Lb.	Kg/Cm	Lb./Sq. In.	Mm/WS	In./Water	Cbm	Cu. Ft.	
Aug. 12, 1912..	2	40	2238	49236	5.1	72.5	5.2	0.20	652.48	23033.	74.9
May 2, 1913...	2	35	2424.5	53339	4.85	68.2	5.2	0.20	654.08	23086.	80.2

The author states that the efficiency of such boilers has been hitherto only assumed, the difficulty of measuring the amount of gas consumed being such as to make the results of tests generally unreliable. He had at his disposal a gasometer of known volume, and could therefore measure the gas consumed with the desirable degree of precision. The tests were made with a double-flue boiler, of about 90 qm (968 sq. ft.) heating surface fired by a blast-furnace gas and a similar boiler, 86 qm (925 sq. ft.) heating surface fired by coke-oven gas, both with economizers, superheaters, and Terbeck burners built into the flues.

The efficiencies obtained (Table 1A) for the coke-oven gas-fired boiler are 74.9 and once as high as 80.2 per cent. In both tests the quantity of gas was somewhat too low, so that the gas pressure was only 5.2 mm (0.20 in.); the water evaporated per hour per qm was therefore only 11.8 and 12.8 kg. (2.4 and 2.6 lb. per sq. ft. per hour). With the increase in the gas pressure, the boiler output and efficiency are expected to increase materially. Table 1B contains data of tests of a double-flue boiler with corrugated flue tubes 90 qm (968 sq. ft.) heating surface and 56 qm

TABLE 1B EVAPORATION TESTS, BLAST-FURNACE GAS-FIRED BOILER

	Test No. 1	Test No. 2	Test No. 3
Duration of test, hours	1	1	1
Gas, per cent			
Dust content	0.038/cbm = 0.4 grains per cu. ft.		
CO_2	12.4	11.4	11.4
O	....	....	....
CO	26.6	27.4	27.4
H	4.8	4.2	4.0
N	56.3	57.0	57.2
Heating value, cal	946	897	895
Temperature, deg. cent./fahr	15/56	19/66.2	19/66.2
Air temperature, deg. cent./fahr	18/64.4	23/73.4	23.5/74.3
Barometer, mm/ in. mercury	738/29.04	746/29.35	746/29.35
Gas pressure in piping in front of furnace, mm/ in. water	19/0.74	25/1	25/1
Gas consumption, cbm/cu. ft. per hr	1425/50302	1515/53479	1353/47761
Feedwater			
Consumption, kg/lb	1519/3342	1280/2816	1380/3036
Temperature in front of economizer, deg. cent./fahr.	18/64.4	21/69.8	21/69.8
Same behind economizer, deg. cent./fahr	66/150.8	105/221	104/219.2
Evaporation per hour per qm/sq. ft. heating surface	16.8/180	14.2/152	15.4/165
Evaporation per qm/sq. ft. per hour of water at 0 deg. cent. (32 deg. fahr.) and steam at 100 deg. cent. (212 deg. fahr.), kg./lb	18/39.6	14.2/31.2	15.8/34.7
	Test No. 1	Test No. 2	Test No. 3
Steam			
Average gas pressure, atmospheres	5.3	5.6	5.6
Corresponding temperature, deg. cent./fahr	160/320	162/323.6	162/323.6
Heat of generation of saturated steam, WE per kg/B.t.u. per lb	661/1190	662/1191.6	662/1191.6
Superheat, deg. cent./fahr	335/635	321/609.8	343/649.4
Heat of generation of superheated steam according to Mollier J-P diagram, WE per kg/B.t.u. per lb.	752/1354	744/1339	756/1361
Evaporation			
Water evaporated, kg/lb. per kg/lb. of gas	1.02/1.02	0.85/0.85	1.01/1.01
Exhaust Gases			
Temperature, deg. cent./fahr	285/545	290/554	295/563
Analysis			
CO_2	23.4	24.1	23.3
O	....	0.8	1.0
CO	3.4	....	0.2
Draft, mm/in. water			
In furnace	12/0.47	10/0.4	10/0.4
In chimney	20/0.8	15/0.6	13/0.507
Heat Balance, per cent			
a Steam generation	64.5	61	63
b Superheating	9.7	7.8	10.3
c Heating water in economizer	5.2	8.0	9.4
Efficiency			
Including the economizer	79.4	76.8	82.7
Excluding the economizer	74.2	68.8	73.3

TABLE 1C HEAT CONSUMPTION OF A GAS ENGINE AT VARIOUS LOADS

	Test No. 1	Test No. 2	Test No. 3
Load, kw	1920	1600	412
Load, per cent	87	73	18.8
Heating value of gas, WE/B.t.u	976/1757	934/1681	884.6/1592.3
Gas consumption per kw/hour, cbm/cu. ft	3.8/128.2	4.5/158.8	10.2/360.0
Heat consumption per kw/hour, WE/B.t.u	3709/14687	4203/15644	9003/35652

(602 sq. ft.) superheater surface. The tests which are stated to have been conducted in a very exact and scientifically correct manner have shown efficiencies of 76.8, 78.4 and 82.7 per cent. The variation in efficiency was due to varying the admission of gas and air, so that, e.g., in the first test with CO content in the exhaust gases of 3.4 per cent, the efficiency was 79.4 per cent, while in the third test with only 0.2 per cent CO it rose to 82.7 per cent. On the average, however, with proper attendance, the efficiency of a gas-fired boiler may be taken to be between 78 and 80 per cent. Some sort of pressure-regulating device ought to be installed in the piping, to keep the gas pressure uniform.

The ability to measure correctly the amount of gas consumed was further used to make heat consumption tests on gas engines. Table 1C gives the data of a test on an engine driving a dynamo, the engine having 1300 mm (51.2 in.) bore, 1400 mm (55.1 in.) stroke at 94 r.p.m. rated at 3000 to 3100 effective horsepowers. Tests were made with a load on the engine of 75 to 80 per cent of full load, which is somewhat more than the usual 73 to 78 per cent.

Data of Tests of a 160-H.P. Superheated Steam Locomobile (*Versuchsergebnisse einer 160-PS-Heissdampflokomobile. Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 35, p. 431, August 29, 1913. Taken from *Lanz's Mitteilungen über Lokomobilen*, 1913, no. 12. *e*). Data of tests made at a German porcelain button factory of a Lanz superheated steam compound locomotive used as a driving engine at the factory. It has condensation by injection, is rated at 160 h.p., but may be loaded up to 200 h.p. for a long time, and up to 225 h.p. for a brief time. Normal speed is 190 r.p.m. The data of the tests (average values) are given in Table 2.

TABLE 2 DATA OF TESTS OF A LANZ SUPERHEATED STEAM LOCOMOBILE

Duration of test, min.	377
Output on brake during test, h.p.	160.7
Admission, per cent	25.6
Mechanical efficiency, per cent	91.6
Average speed, r.p.m.	191.4
Boiler pressure, atmospheres	12
Steam temperature at entrance to high pressure cylinder,	
deg. cent.	292.4
deg. fahr.	558.3
Steam consumption per effective horsepower per hour,	
guaranteed, kg/lb.	5.3/11.66
actual, kg/lb.	5.18/11.4
Coal consumption per effective horsepower per hour at 7500 WE (B.t.u. per lb.)	
guaranteed, kg/lb.	0.58–0.61/1.27–1.34
actual, kg/lb.	0.571/1.256

The guarantee applied only to coal containing not more than 5 per cent ash and slag residue.

Report of the Association for the Inspection of Boilers in the Mines of the Dortmund Mining District for the Year 1912-1913 (*Bericht des Dampfkessel-Überwachungs-Vereines der Zechen im Oberbergamtsbezirk Dortmund über das Geschäftsjahr* 1912-1913. *Glückauf*, vol. 49, no. 31, August 2, 1913. 3 pp. *g*). Abstract of the report. In the period covered

by the report the Stirling type of boiler made its appearance in the district, and the reporters believe that, while the fire-flue boiler will for some time to come maintain its leading position for certain classes of work, and particularly for plants with operation of mixed nature, the Stirling boiler will come into strong competition with the water-tube boiler. Tests to establish definitely the value of this type of boiler are now under way.

The report contains also data of tests of burning coal dust in a tar-oil fired furnace under a fire-tube boiler. The coal dust was falling into the oil flame from above. The small particles burned at once, while the larger ones fell on a special grate, and burned more slowly, with a long clear flame. Coal dust consumed per hour was 18 kg (39.6 lb.) of tar-oil and 190 kg (41.8 lb), with a steam generation of 16 kg per 1 qm (say 3.3

TABLE 3 BENDING AND TORSION STRENGTH OF WINDING ROPES

Kind of Rope	Diameter, Mm.	Bendings, Average	Minimum	Torsions	
				Average	Minimum
Good.........	5	21.4	18.5	46.4	39.9
Poor..........	...	18.3	13.7	24.2	4.3
Standard......	...	....	11	....	23
	1.8	....	....	....	....
Good.........	...	16.5	14.8	43.6	32.3
Poor..........	...	15.3	14.0	25.2	11.5
Standard......	...	....	9	....	21
	2.0	....	....	....	....
Good.........	...	13.6	12.4	34.5	26.8
Poor..........	...	12.9	12.0	27.5	19.5
Standard......	...	....	7	....	19
	2.8	....	....	....	....
Good.........	...	8.0	7.1	28.3	17.4
Poor..........	...	6.2	5.6	12.9	1.4
Standard......	...	....	4	....	11

lb. per sq. ft.) heating surface. Extensive tests are to be made also of the surface combustion, and the report points out that if the promises of 95 per cent efficiency prove true, a revolution in the power production in favor of steam may be expected in the district.

Strength of Materials

Torsion Strength (*Torsionsfestigkeit.* O. Speer. *Der Bergbau,* Vol. 26, no. 33, p. 531, August 14, 1913. $1\frac{1}{2}$ pp. *ce*). The author insists on the insufficiency of bending tests, and superiority of torsion tests in which the torsion is measured by the angle of twist, for determining the strength of winding ropes. A comparatively weak rope may, in bending tests, give fairly good results, but its weakness is instantly revealed by torsion tests. Table 3 gives average results obtained by the author in his tests (made on behalf of the German Winding Rope Commission), in which every figure stands for an average of ten tests.

The author states further that in his long practice of testing winding

ropes he never ran across a case where a new rope had to be rejected on account of damage which it had undergone in packing or transportation.

Miscellanea

The Project of the New Patent and Trade Mark Law (*Zu dem Entwurf für das neue Patent-, Gebrauchsmuster- und Warenzeichengesetz*, E. Bierreth. *Dinglers polytechnisches Journal*, vol. 328, no. 33, p. 513, and no. 34, p. 537. 5 pp. *d*). Exposé and criticism of the new German patent law, covering patents, limited patents (*Gebrauchsmuster*) and trade marks. The more interesting provisions of the project are as follows: The yearly payments are considerably reduced (50 marks for each of the first five years, and a progressive addition of 50 marks each following year up to the end of the life of the patent, making a total of 3500 marks, instead of 5280 marks as now). On the other hand, all the other fees are materially increased: application fee from 20 to 50 marks, appeal fee in the same proportion; anybody objecting to the grant of a patent must pay a fee of 20 marks, and is liable to pay costs if his objection is not sustained. An objection alleging lack of patentability involves a fee of 100 marks, and an appeal to the Imperial Court on that ground, a fee of 300 marks. The invention of an employee belongs to the employer, in the absence of special agreements covering this case, if the invention is in a field within the regular work of the employee; but the employee has a right to a compensation for his invention, and may insist on being named as the inventor. Patents are to be granted to the real inventor, and not the first applicant, as heretofore. The procedure in the patent office is somewhat simplified, and the period of the life of the patent is made to start from the date of the publication of the application, and not from that of the filing of the application as now. "Restoration into the original state," i.e., action after statutory date, is permitted in a number of cases, e.g., appeals, etc., but not in the case of failure to pay on time the yearly fees, in which case the lapse appears to be irreparable.

NECROLOGY

EDWARD MINER ADAMS

Edward Miner Adams was born in Pittsburgh, Pa., July 19, 1868, and went to Crestline, Ohio, when two years of age. He had only a common school education, being obliged to work in the Pennsylvania Railroad shops when thirteen years old. Here he learned boiler making and the coppersmith's trade. Later he went to Bucyrus, Ohio, where he was employed by the Thompson Steam Shovel Company as machinist. In 1892 he moved to Akron, Ohio, and worked as machinist with the Akron Machine Company. After three years he accepted an offer from the American Cereal Company, later the Quaker Oats Company, and in 1898 attained the position of machine shop foreman. In the same year he was made chief engineer in addition to his other duties, a position he retained until the time of his death on April 17, 1913.

Mr. Miner was president of the Ohio Society of Mechanical, Electrical and Steam Engineers, having been chosen to serve a second term; also a member of the Akron Chamber of Commerce.

FRED H. DANIELS

Fred H. Daniels was born at Hanover, N. H., June 16, 1853. Immediately after graduation from Worcester Polytechnic Institute he entered the employ of Washburn & Moen Manufacturing Company as draftsman and came under the direct supervision of Charles H. Morgan, general superintendent of the company. Soon afterwards he was transferred to the machine shop and in this department of the works obtained an experience which proved of infinite value in his later career as an engineer and manufacturer of wire rods and wire.

About the year 1874 his company thought it imperative that a laboratory in charge of a competent chemist be added to their works, and decided to send Mr. Daniels to study under Thomas M. Drown of Lafayette College, Easton, Pa. Here he remained 18 months, and then was sent, in company with Mr. Morgan, to study the state of the wire industry in England, France, Germany, Norway, Sweden

and Belgium. He returned to Worcester in April 1876 and again took charge of the drafting room and laboratories, where he inaugurated new and advanced practice based upon his investigations. In 1878 he accompanied Mr. Morgan abroad a second time to inspect a continuous mill with horizontal rolls in Germany. Practically all continuous mills heretofore had alternating horizontal and vertical rolls, a combination possessing great disadvantages. Upon their return to Worcester they were granted patents on the horizontal rod mill as well as on the reels, and a mill was built which proved to be very successful. The tonnage was doubled and rods two sizes smaller than had ever been rolled were produced. The invention revolutionized the art of rod rolling throughout the world. Both the reels and the mills are now almost in universal use, reducing the cost of rolling $2.50 per ton.

Shortly afterwards Mr. Daniels was promoted to the position of superintendent of buildings, retaining charge of the drafting room and laboratories. In 1887 upon the resignation of Mr. Morgan from the company, P. W. Moen was made general superintendent and Mr. Daniels assistant general superintendent of all the Washburn & Moen plants. About this time the business had grown to such proportions that it was decided to open a second plant at Waukegan, Ill. Mr. Daniels designed and superintended the construction of the buildings having an output of 800 tons per day of all kinds of wire rods and wire. After acting as assistant general superintendent for a year, he was promoted to general superintendent, and in 1895 was sent to San Francisco, where in conjunction with Frank L. Brown, Pacific coast sales agent, he established the Hallide works, known as the California Wire Works. In 1898 the Washburn & Moen Manufacturing Company was taken over by the American Steel & Wire Company and Mr. Daniels became engineer of their 30 plants. He was given the responsibility of putting a number of rundown properties into first class condition, and the business was then sold to the United States Steel Corporation. Mr. Daniels was appointed chairman of the board of engineers, in charge of 143 plants.

During 1902 and 1903 Mr. Daniels designed and constructed at San Francisco the Pacific coast works of the American Steel & Wire Company. In 1907 he was delegated to go abroad by his company to inform himself fully regarding rolling mills for producing hot rolled flats. Simultaneously the United States Steel Corporation authorized him to negotiate for the purchase of a shop right for its plants in the patented device of O. E. Theisen of Munich for purifying blast-furnace gases.

In 1907 and 1908 he designed and constructed for his company the Cuyahoga works at Cleveland, and in 1910 and 1911 their Birmingham works.

Mr. Daniels was a member of the American Institute of Mining Engineers, the American Society for Testing Materials, the Iron and Steel Institute of Great Britain, the American Iron and Steel Institute, and was a Life Member and Past Vice-President of the Society. He died August 31, 1913.

CHARLES SIMEON DENISON

Charles Simeon Denison was born at Gambier, Ohio, July 12, 1849, and was educated at the high school at Lockport, N. Y. He spent one year at Norwich University, Northfield, Vt., where he acquired a military training. In 1871 he was graduated from the University of Vermont with the degree of C.E.; in 1874 he received the degree of M.S.; and in 1907 the honorary degree of Sc.D. was conferred upon him by his alma mater.

He was assistant engineer in construction of the Milwaukee and Northern Railroad from 1871 to 1872, and since then had been instructor at the University of Michigan, rising through various positions to head of the mechanical drawing department, which he held at the time of his death on July 30, 1913.

Mr. Denison was United States astronomer and surveyor in locating the boundary line between Washington and Idaho territories in 1873 and 1874. The accuracy of his work upon this survey, accomplished largely in the winter under severe conditions and great hardships, was fully established by a recent expedition sent out by the United States Government for placing permanent markers on the boundary. He was a member of the Society for the Promotion of Engineering Education, the Michigan Engineering Society, Detroit Engineering Society, and an honorary member of Tau Beta Pi, and was the author of numerous published essays and lectures on scientific subjects. He had been an extensive traveler in America and Europe, largely in the interest of his work at the University of Michigan.

EDWARD J. MURPHY

Edward J. Murphy was born in the province of Ulster, Ireland, February 5, 1829. He was educated in the private schools of Dublin, his training being that of civil engineer. In 1849 he came to America, and the following year made surveys in Ohio for a Phila-

delphia map publishing company, and later did the same kind of work in the central part of New York. In 1853 he became first assistant to the city surveyor of New York, helping to lay out many of the street car lines of the city. Two years later he went to Hartford as chief draftsman for the Woodruff & Beach Iron Works, and although the work was somewhat different from that of a civil engineer, he gave complete satisfaction from the first, and continued with the firm until its dissolution. In this capacity he was connected with some of the most important work for the government during the Civil War, being identified in the designing and constructing of the machinery for the United States sloops of war Mohican and Kearsarge and also with the gunboats Pequot and Nipsic, and later with the three large sloops of war Piscataqua, Minnetonka and Manitou.

After the war the Nelson Mining Company was organized in Hartford and Mr. Murphy went to Montana to look after the interests of Woodruff & Beach, in the hope that the change would improve his health which had become impaired. Soon after his return the Hartford Foundry & Machinery Company was formed to succeed the old firm of Woodruff & Beach, and Mr. Murphy was elected secretary and treasurer of the company at its organization in 1872. In 1878 he was elected president of the Board of Water Commissioners, from which he resigned two years later to accept an appointment of superintending engineer at the factory of the Colt Patent Fire Arms Manufacturing Company. He remained with this firm until 1889 when he resigned to become the consulting engineer of the Hartford Steam Boiler Inspection & Insurance Company. He died September 2, 1913.

Mr. Murphy was honored with many places of public and private trust during his long residence in Hartford. He was one of the charter members of the Society and an associate member of the United States Naval Engineers' Society.

ELMER A. SAMMONS

Elmer A. Sammons was born in Cheboygan, Mich., March 31, 1860, and at the early age of 15 was made captain of the steamer Minnie Sutton, on Lake Superior. In 1880 he moved to Cincinnati, where he carried on a general consulting business for the following firms: George Enger Carriage Company, Miller Plating Works, Union Laundry Company, T. A. Snyder Preserve Works, Henry Geiershoffer Clothing Company, and W. H. Meredith and Company,

general machinists. He conducted a night school from 1885 to 1888 in connection with the Marine Engineers Beneficial Association, of which organization he was president and vice-president. In 1888 Mr. Sammons went to Louisiana where he took charge of the sugar refinery of James H. Laws & Company at Cinclare, and three years later he remodeled the entire plant, installing the revolving grate bar, one of his own patents, which proved to be so successful that it was put into practically every large factory throughout Louisiana. During this time he also superintended the erection of the A. Wilbert Refinery at Plaquemine, La. Mr. Sammons moved to New Orleans in 1903 and engaged in the general machinery business, one of his greatest undertakings being in connection with the sugar refinery at Thibodaux. He died at New Orleans, July 4, 1913.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Trans., vol. 34, 1912. *New York, 1913.*

BRIDGES OF CLEVELAND, H. G. Tyrrell. (Reprint from The Ohio Architect, Engineer and Builder. Gift of author.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS. Papers and Trans. for 1912. *New Haven, 1913.* Gift of society.

COURS D'AÉRONAUTIQUE, L. Marchis. 3 vols. *Paris, Dunod et Pinat, 1910-1912.*

These three volumes which are lithographed, as is quite usual with professorial lectures in France, are certain proof of the rapid advance in the science of aviation: ten years ago a work of 1000 pages on aviation would be impossible. The author is professor of aviation in the University of Paris.

DEUTSCHER BETON VEREIN. nos. 1-3. *Berlin.*

ELECTRIC POWER FROM THE MISSISSIPPI RIVER. (Mississippi River Power Co. Bulletin no. 10.) *Keokuk, 1913.* Gift of Mississippi River Power Co.

ELEKTRISCHE KRANAUSRÜSTUNGEN DER SIEMENS-SCHUCKERTWERKE NACH 25 JAHRIGER ENTWICKELUNG. pts. 1, 2. *Berlin, 1913.*

JOHN FITCH. The first in the world's history to invent and apply steam propulsion of vessels through water. *1912.* Gift of Francis B. Allen.

DIE FÖRDERUNG VON MASSENGÜTERN, Georg von Hanffstengel. ed. 2, vol. 1. *Berlin, 1913.*

LE FROID INDUSTRIEL, L. Marchis. *Paris, Felix Alcan, 1913.*

The author is professor in the University of Paris. The volume, although small and inexpensive, summarizes in a remarkable way the art as it exists to-day. This is the kind of book that the United States Senate contemplated taking from the free list.

GAS ENGINE HANDBOOK, E. W. Roberts. *Cincinnati, Gas Engine Publishing Co., 1913.*

This edition of a well-known handbook has been rewritten, new matter being added, specially in the discussion of frame design and in the directions for tests.

HANDBUCH FÜR EISENBETONBAU, F. von Emperger. ed. 2, vol. 9. *Berlin, 1913.*

DIE HEBEMASCHINEN, August Pohlhausen. *Leipzig, 1898.*

ILLUSTRIRTE ZEITUNG. Gas-Jahrhundert-Nummer. Entstehung des Kohlengases. Gift of Paul Gerhardt.

Imperial College of Science and Technology and City and Guilds of London Institute. Prospectus of the City and Guilds (Engineering) College, August, 1913. *London, 1913.* Gift of Imperial College of Science and Technology.

Jahrbuch der wissenschaftlichen Gesellschaft für Flugtechnik. vol. 1. 1912-13. *Berlin, 1913.*

Leeds Commercial Year Book. (English, French and Spanish.) 1913. *Leeds, 1913.* Gift of Chamber of Commerce of Leeds.

Mechanical and Refrigerating Engineers' Handy Book, Otto Luhr, with the collaboration of E. T. Henius. *Chicago, Wahl-Henius Institute, 1913.*

This work of about 900 pages is designed for the use of refrigerating and steam engineers. After chapters devoted to elementary physics, electricity and chemistry, it treats of furnaces, boilers, engines, power transmission, pumps, compressors, and finally, of refrigeration and its applications. Numerous useful tables and a most comprehensive index are provided.

Osterreichischer Ingenieur und Architektenverein. Jahrbuch 1913. *Wien, 1913.* Gift of society.

——Reform des technischen Hochschulwesens in Osterreich. April 26, 1913. *Wein, 1913.* Gift of society.

Permanent International Association of Navigation Congresses. Proc. 12th congress, Philadelphia, 1912. *Brussels, 1912.*

Practical Metallography of Iron and Steel, J. S. G. Primrose. *Manchester, England, Scientific Publishing Co.*

While primarily designed as a textbook of moderate price, this volume summarizes the processes and results of metallographic investigation in such a way as to make it a valuable addition to the library of any engineer.

Producer Gas, J. E. Dowson and A. T. Larter. ed. 3. *London-New York, 1912.*

Resistance of the Air and Aviation, G. Eiffel, translated by H. C. Hunsaker. ed. 2. *London, 1913.* Gift of G. Eiffel.

This work of a distinguished honorary member of the Society makes available in English an authoritative account of the extremely valuable and interesting laboratory experiments made by him in Paris. The original French edition has been supplemented by an account of the later experiments at Auteuil, which were originally published in the Mémoires of the Société des Ingenieurs Civils.

Rules of Management, with Practical Instructions on Machine Building, William Lodge. *New York, McGraw-Hill Book Co., 1913.*

The author is president of a large machine tool company; this book seems to have been written in chapters, each giving a general summary of the duties of some particular official or employee in such a company. The style is direct and clear cut, and the chapters short. It should be extremely valuable to every machine shop employee. Suggestions are given for the establishment of a pension system.

Sayings and Writings about the Railways, by those who have managed them and those who have studied their problems. *New York, 1913.* Gift of Bureau of Railway Economics.

Science of Burning Liquid Fuel, a Practical Book for Practical Men, W. N. Best. *1913.* Gift of author.

The author has had years of practical experience in the use of fuel oil and has designed and patented numerous appliances for its economical use. The volume is largely devoted to the description of this apparatus.

THE TECHNICAL PAPERS OF ARIYA INOKUTY. *Tokyo, 1913.* Gift of the Celebration Committee.

Professor Inokuty has occupied the chair of engineering in the Tokyo University for 25 years, and the present volume is a beautiful tribute from his former pupils and from friends. It contains a reprint of his technical papers, 43 in number, of which 11 are in the Japanese language, the remainder in English. The volume is beautifully printed.

THAYER SCHOOL OF CIVIL ENGINEERING. Annual for 1909-1912. *Hanover, 1909-1912.* Gift of Dartmouth College.

THEORY AND DESIGN OF STRUCTURES, E. S. Andrews. ed. 3. *London, Chapman & Hall, 1913.*

——Further Problems in the Theory and Design of Structures, E. S. Andrews. *London, Chapman & Hall, 1913.*

These contain advanced problems for the use of students and draftsmen.

THEORY OF HEAT, Thomas Preston, revised by J. R. Cotter. ed. 2. *London, 1904.*

GIFT OF M. K. DE MEYENBURG

La motoculture par tracteurs ou machines rotatives.

Motorkultur-Maschine (system v. Meyenburg) für hochwertige, neuzeitliche Feldbestellung.

Motorlaftwagen und Motorpflüge. (Sonderabdruck "Mitteilungen der Deutschen Landwirtschafts-Gesellschaft, 1910.")

Motorpflüge und Bodenfrasmaschinen. (Sonderabdruck "Jahrbuch der Deutschen Landwirtschafts-Gesellschaft, 1912.")

Le rendement du tracteur agricole.

EXCHANGES

ENGINEERS' CLUB OF SAINT LOUIS. 18th Annual Bulletin. 1913.

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings. vol. 192. *London, 1913.*

WISCONSIN GAS ASSOCIATION. Proc. 12th annual convention. *Milwaukee, 1913.*

EXCHANGE ACCOUNT—UNIVERSITY OF MICHIGAN

AERONAUTICS. vol. 1, nos. 12, 13. *London, 1908.*

GRANITE CUTTERS' JOURNAL. vol. 32, nos. 10-12, 1909; vol. 35, nos. 1-12. *Quincy, Mass. 1909, 1911.*

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS. Proc., 1899, 1903.

IOWA CIVIL ENGINEERS AND SURVEYORS SOCIETY. Proc., 1895, 1896.

OHIO SOCIETY OF SURVEYORS AND CIVIL ENGINEERS. 16th, 17th annual report, 1895-1896.

THE TECHNOGRAPH. vols. 11, 15-19. *Urbana, 1897, 1901-1905.*

THE TRANSIT. vols. 5, 7. *Iowa City, 1897, 1899.*

VALVE WORLD. vol. 1, no. 5; vol. 3, no. 11. 1905, 1907.

ZEITSCHRIFT FÜR DAS GESAMTE TURBINENWESEN. Yr. 3, nos. 1-2, 4-6, 8-11, 15-36. *Berlin, 1906.*

UNITED ENGINEERING SOCIETY

NEW YORK TIMES INDEX. January-June (2 vols.). *New York, 1913.*

LES NOUVEAUX LIVRES SCIENTIFIQUES ET INDUSTRIELS. vols. 1-2, 1902-1912. *Paris, 1908, 1913.*

Progress of German Shipbuilding, with special reference to the evolution of the fleet of the Norddeutscher Lloyd. (English-German.) *Berlin, 1909.* Gift of North German Lloyd Steamship Co.

Trow's General Directory of the Boroughs of Manhattan and Bronx, City of New York. vol. 127, 1913. *New York, 1913.*

TRADE CATALOGUES

Edge Moor Iron Co., *Edge Moor, Del.* Bull. 51, tests of a steam boiler at high rates of evaporation made at the Westport Generating Station Consolidated Gas Electric Light and Power Co. of Baltimore, 1913.

Asbestos Protected Metal Co., *Beaver Falls, Pa.* Bull. 53, asbestos steel for roofs and walls, 1913.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

801 Member, or member's son, with business ability and $10,000, can secure equal partnership with full financial control and management in new concern, to engage in the manufacture of a complete line of machinery fully covered by patents. Sales in the last three years, $100,000.

808 Young man of good education and foundry experience wanted for time-study and rate-setting work. Positions available in both steel and grey iron foundries. Location, St. Louis, Mo.

901 Partner with capital up to $20,000, to become associated with two expert mechanical engineers who have had broad experience in all English, French and American automobiles, and who desire to exploit a new engine.

904 Pennsylvania concern desires to communicate with competent men for position of assistant superintendent. Applicants must have thorough knowledge of both light and heavy machine production.

905 Young engineer of about 30 years of age wanted for planning, estimating and arranging for factory orders, of concern engaged in the manufacture of exterior and interior house furnishings, trim, and cabinet work.

906 Moderate sized plant manufacturing picture moldings desires superintendent; must be a manager of men and a good executive, thorough and energetic, with sufficient experience to show ability. In reply state salary expected, education, experience in full, age and references. Apply through the Society .

910 Assistant chief inspector. Technical graduate, with practical electrical and mechanical experience. If competent, would have charge of inspectors throughout the works. Applicant must be active, energetic, of highest moral character, and impartial, and a man of determination. Would be in direct line for promotion to chief inspector. About 30 years of age. Salary to start from $25 to $30 per week according to man's ability. Location, Massachusetts.

911 Assistant superintendent; American, 35 to 40 years of age; married; technical graduate, either mechanical or electrical, with practical experience in both branches; a good executive capable of handling manufacturing sections of works, employing about 1500 hands in manufacture of heating devices of all descriptions, enameled and cotton-covered

wire, lightning arresters and screw machine products. Must have experience on light sheet metal work, deep drawn work, small interchangeable manufacture, etc., to instruct tool department in kind of tools required, approximate cost of same, estimate probable cost of new products. Must be neat and orderly, energetic, and of the highest moral caliber. Salary $2000 to $3500 per year, according to applicant's past experience and record. Location, Massachusetts.

912 Foremen with experience on windings of various kinds, as motors, transformers, etc., with electrical experience, thoroughly posted on reading blue prints. Must be thorough executive, about 40 years of age, with about five years' experience in handling men and successful record in getting out work, both as to quality and quantity, without antagonizing workmen. Would probably be required to start as assistant foremen. Department would have from 60 to 125 men. Salary $27 to $32 per week. Location, Massachusetts.

914 Consulting engineer, Member of the Society and of the A.I.E.E., engaged in power and industrial work and general engineering practice in New York City, and extending through the southern states, desires partner who is not entirely dependent on present income and who can invest $1000. Applicant must be graduate mechanical or civil engineer with few years' experience in building construction and machinery installation, including steel and concrete work.

915 Mechanical engineer to take complete charge of drafting room, design of machinery, buildings and equipment. Location, New Jersey.

918 One or two technical men wanted on experimental and testing work in the steam engineering department of Buffalo concern. Work consists of general steel plant, inspecting, etc., such as furnaces, gas producers, engines and boilers, etc.

919 Man for permanent editorial position who knows power plant practice. Must be able to carry large responsibility and develop ideas. Young man preferred, willing to travel in western states. Apply through the Society.

921 Consulting engineer requires as assistant competent mechanical engineer having practical experience with mining machinery, coal-handling appliances and electrical installations. Must be competent to take charge of plants and carry out instructions as to operations, repairs and the purchase and installation of new equipment. Preferably a young man. Location, New York, but must be willing to travel. Moderate salary to begin, but exceptional opportunities if satisfactory. Apply through the Society.

923 Shop superintendent to take charge of the manufacturing operations for new Canadian plant making a general line of dairy machinery. Must have had experience in manufacturing. Apply through the Society.

MEN AVAILABLE

220 Mechanical engineer, Massachusetts Institute of Technology; three years' practical experience in power plant, efficiency engineering and concrete building construction.

221 Exclusive agency in New York for any kind of machinery desired by experienced engineer and salesman.

222 Member desires position as executive manager or general superintendent; practical and technical. Aggressive, broad gage, initiative, exceptional ability acquired by wide experience in manufacturing in plants employing 3000 men, which he has built and operated. Has tact and business ability, good organizer. Desires to connect with manufacturing, constructing or operating engineering company. Steam, hydraulic, electric and power installation work or in connection with consultation, examination, appraisal, design, organization, construction, operating, maintenance and commercial extension.

223 Member, graduate mechanical engineer, now employed, desires change; 15 years' experience in design, construction and maintenance of power and heating plants, industrial plant equipment, cost estimating, familiar with design and manufacture of automobiles, transmission and hoisting machinery; several years' shop training; competent to fill position of chief designer, factory engineer or superintendent; would consider teaching position with large engineering school.

224 Sales engineer desires position where knowledge of machinery and mill supply trade in United States and Canada is essential; seven years' varied experience, nine years in selling end. Experience in correspondence and design of selling contracts.

225 Member, 20 years' varied experience in designing, building and operating; now in charge of large construction work nearing completion; surface equipment of mines and gravel plant; has made special study of economical methods of handling materials; accustomed to handling men, organizing crews, drawing up contracts, designing and purchasing; desires connection with some firm handling large work. At present employed on Pacific coast.

226 Junior member, age 27, technical graduate, aggressive and energetic, employed by large steel company for past four years; familiar with operation and testing power plant machinery and maintenance of steel mill equipment; desires position with opportunity for advancement; at present employed. Middle West preferred.

227 Member desires position as mechanical superintendent in manufacturing plant; has held such position with large textile mills in New England for several years; conversant with mill construction, power plant installation and operation; electric transmission and general repair and care of large properties; first class references; holds first class steam engineer's license for Massachusetts.

228 Member having sold interest in eastern concern which he built up from a $10,000 business to $100,000 per year, is open for engagement. Experienced as machinist, marine engineer, tool, punch and die maker, designer, foreman, salesman and manager, including purchasing, selling and credits. 38 years old. Prefers middle, far west or foreign location.

229 Junior, mechanical engineer, technical graduate, Purdue University, 15 years' experience machine shop, drawing room, erecting large machinery, construction work and operating power plants of steam and gas engines.

230 Junior, 25 years of age, desires position with power company or contracting and consulting firm doing power plant work; technical graduate; experience in power plant of large manufacturing company.

231 Junior member, age 31, seven years' experience in boiler manufacture and general steel plate work, detailing, designing, testing, estimating and assistant manager; two years engine salesman; desires responsible position offering good opportunities; graduate of prominent engineering school; salary $2400.

232 Rensselaer graduate mechanical engineer, located since graduation with automobile concern, doing practical shop work; knowledge of Spanish; wishes better position.

233 Sales engineer with largest manufacturer of power and mining machinery in the Middle West desires to make a change. Excellent references can be furnished.

234 Member, long experience on light and medium weight manufacturing, desires position as works manager or general superintendent.

235 Junior, technical graduate, desires position with consulting engineer, manufacturing concern. Six years' experience in general machine shop work, power, heating and ventilating plant design and construction; expert on high and low-pressure piping; good knowledge of modern manufacturing methods; 32 years old, energetic and systematic; married. Best references; New York district preferred.

236 Graduate engineer, age 42, Member of Society and Associate of American Institute of Electrical Engineers; married, experience teaching electrical and mechanical engineering, construction of small and large buildings in wood, brick or concrete. Can take charge of any constructive work or head position in mechanical or electrical engineering in a college or industrial work, also charge of power plant work.

237 Member, graduate mechanical engineer, age 34, capable designer, practical foundry and shop man, desires position as engineer, superintendent, manager or assistant; broad engineering experience as mechanic and executive in plant, shop and office, in heavy machine building and light interchangeable manufacture; salary commensurate with position.

238 Technical graduate, age 40, with 20 years' experience in teaching, commercial testing, consulting and factory management; also two years selling; has been works manager for large concerns in United States and Canada; specialty factory building, equipment and organization.

239 Member, age 47, at present employed, desires permanent engagement as factory manager or superintendent; wide experience in varied lines of light manufacturing, such as typewriters, guns and special automatic machinery; resourceful and inventive.

240 Consulting engineer, electrical-mechanical; Member of the Society and of A.I.E.E., is open for engagement as teacher, instructor or lecturer in technical night schools in or near New York City.

241 Mechanical-electrical engineer, progressive diplomatic business man, with character, initiative and proven ability; a technical graduate and Member of the Society and A.I.E.E. Fifteen years' exceptional experience in the design, installation and operation of power and industrial plants, distribution systems (especially underground) and hydraulic work, including marine practice; drafting, original research, contracting, manufacturing, consulting engineering and the application of scientific management to the above operations; age 33, American, traveled throughout the

East, South, and Middle West. Now employed; desires responsible position or partnership with an established engineer in or near New York City. Salary is of secondary consideration.

242 Member, mechanical engineer, 37 years of age, 12 years' experience in harvester and implement business; served as draftsman, foreman, designer, master mechanic, assistant superintendent and for the past six years as general superintendent; familiar with modern and economical methods of manufacturing, establishing of efficiency by scientific rate-setting.

244 Member, age 37, at present manager of a general machine and structural shop, desires responsible position with machine works in Pennsylvania, eastern part preferred; is in position to make investment in responsible growing concern of this character.

245 Member, experienced as general or business manager, mechanical engineer, salesman and executive; desires position with manufacturing establishment or branch house where this experience will be useful; salary $3000.

246 Technical graduate, desires position requiring engineering, executive, or confidential ability, or to become associated with a firm of consulting, purchasing or inspecting engineers; practical manufacturing experience in iron and steel castings and machinery; can thoroughly satisfy anyone looking for a man of exceptional experience and ability.

247 Graduate mechanical engineer, age 36. At present employed in executive sales position, but desires to change for better and more permanent work in or near New York. Excellent experience in engineering, purchasing and sales work with consulting, manufacturing and selling concerns.

248 Mechanical engineer, age 29, technical graduate, desires position as assistant plant or mechanical engineer. Experienced in maintenance of large manufacturing plant, inspection, and design of electrical and mechanical equipment.

249 Superintendent or chief engineer for maintenance, design, construction and operation of industrial plants. East or Middle West preferred. Technical graduate.

251 Member, 35 years of age, graduate of Cornell University; wide experience in design, construction and operation of power plants and other machinery; design and superintendence of mill-building construction; desires position with large corporation as supervising engineer to take complete charge of all power operation, repairs and new construction work. At present employed and will consider only high-grade position.

252 Young engineer, five years' practical experience in design, erection and operation of power plants. Junior member.

OFFICERS AND COUNCIL

President

W. F. M. Goss

Vice-Presidents

Terms expire 1913

Wm. F. Durand
Ira N. Hollis
Thos. B. Stearns

Terms expire 1914

James Hartness
I. E. Moultrop
H. G. Stott

Managers

Terms expire 1913

D. F. Crawford
Stanley G. Flagg, Jr.
E. B. Katte

Terms expire 1914

Chas. J. Davidson
Henry Hess
Geo. A. Orrok

Terms expire 1915

W. B. Jackson
H. M. Leland
Alfred Noble

Past-Presidents

Members of the Council for 1913

M. L. Holman
Jesse M. Smith
Alex. C. Humphreys
George Westinghouse
E. D. Meier

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

F. R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

W. F. M. Goss, *Chmn.*
Alex. C. Humphreys, *V-Chmn.*
E. B. Katte
E. D. Meier
Geo. A. Orrok
H. G. Stott

STANDING COMMITTEES

Finance

R. M. Dixon (1), *Chmn.*
W. H. Marshall (2)
H. L. Doherty (3)
W. L. Saunders (4)
W. D. Sargent (5)

Meetings

H. de B. Parsons (1), *Chmn.*
L. P. Alford (2)
H. E. Longwell (3)
H. L. Gantt (4)
R. H. Fernald (5)

Publication

G. I. Rockwood (1) *Chmn.*
G. M. Basford (2)
C. I. Earll (3)
I. E. Moultrop (4)
F. R. Low (5)

Membership

Hosea Webster (1), *Chmn.*
Theodore Stebbins (2)
W. H. Boehm (3)
H. C. Meyer, Jr. (4)
L. R. Pomeroy (5)

Library

L. Waldo (4), *Chmn.*
C. L. Clarke (1)
Alfred Noble (2)
W. M. McFarland (3)
The Secretary

Research

R. H. Rice (4), *Chmn.*
L. S. Marks (1)
A. L. De Leeuw (2)
R. C. Carpenter (3)
R. D. Mershon (5)

House

E. Van Winkle (1), *Chmn.*
H. R. Cobleigh (2)
S. D. Collett (3)
W. N. Dickinson (4)
F. A. Scheffler (5)

Public Relations

J. M. Dodge (3), *Chmn.*
J. W. Lieb, Jr. (1)
F. J. Miller (2)
W. R. Warner (4)
G. M. Brill (5)

SOCIETY REPRESENTATIVES

Engineering Education

A. C. Humphreys
F. W. Taylor

General Conference Committee of National Engineering Societies

C. W. Baker
E. D. Meier

Council of A. A. A. S.

A. C. Humphreys
W. B. Jackson

John Fritz Medal

H. R. Towne (1)
J. A. Brashear (2)
F. R. Hutton (3)
J. R. Freeman (4)

Trustees U. E. S.

A. C. Humphreys (1)
F. J. Miller (2)
Jesse M. Smith (3)

SPECIAL COMMITTEES

Research Committee, Sub-Committee on Steam

R. H. Rice, *Chmn.*
C. J. Bacon
E. J. Berg
W. D. Ennis
L. S. Marks
J. F. M. Patitz

Power Tests

D. S. Jacobus, *Chmn.*
G. H. Barrus, *V-Chmn.*
E. T. Adams
L. P. Breckenridge
William Kent
E. F. Miller
Arthur West
A. C. Wood

Pipe Thread Gages

E. D. Meier, *Chmn.*
George M. Bond
A. M. Houser
J. C. Meloon
Chas. A. Olson
Peter C. Patterson
Henry G. Stott

Student Branches

F. R. Hutton, *Chmn.*
Wm. Kent
Geo. A. Orrok

Research Committee. Sub-Committee on Materials of Electrical Engineering

R. D. Mershon

Note—Numbers in parentheses indicate number of years the member has yet to serve.

Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for Care of Same in Service

J. A. Stevens, *Chmn.*
W. H. Boehm
R. C. Carpenter
Richard Hammond
C. L. Huston
H. C. Meinholtz
E. F. Miller

Committee on International Engineering Congress 1915

The President
The Secretary
W. F. Durand
R. S. Moore
T. W Ransom
C. R. Weymouth

Committee on Bureau of Information Respecting Engineering Standards in all Countries

Henry Hess, *Chmn.*
J. H. Barr
Charles Day
C. J. Davidson
Carl Schwartz

Standard Cross-Section Symbols

H. deB. Parsons, *Chmn.*
F. deR. Furman
A. E. Norton
Bradley Stoughton
John W. Upp

Refrigeration

D. S. Jacobus, *Chmn.*
P. De C. Ball
E. F. Miller
A. P. Trautwein
G. T. Voorhees

Conservation

G. F. Swain, *Chmn.*
C. W. Baker
L. D. Burlingame
M. L. Holman
Calvin W. Rice

Tolerances in Screw Thread Fits

L. D. Burlingame, *Chmn.*
Elwood Burdsall
F. G. Coburn
F. H. Colvin
A. A. Fuller
James Hartness
H. M. Leland
W. R. Porter
F. O. Wells

Pipe Threads

E. M. Herr, *Chmn.*
W. J. Baldwin
G. M. Bond
S. G. Flagg, Jr.

———

L. V. Benet, *Paris Rep.*

Research Committee. Sub-Committee on Safety Valves

P. G. Darling, *Chmn.*
H. D. Gordon
E. F. Miller
F. L. Pryor
F. M. Whyte

Changes in the Patent Laws of U. S

W. H. Blauvelt
B. F. Wood
Carl Thomas
Edward Weston
W. E. Winship

Involute Gears

Wilfred Lewis, *Chmn.*
Hugo Bilgram
E. R. Fellows
C. R. Gabriel
C. G. Lanza

Standardization of Filters

G. W. Fuller, *Chmn.*
Jas. C. Boyd
P. N. Engel
J. C. W. Greth
Wm. Schwanhausser

Conference Committee on Engineering Standards

H. G. Stott, *Chmn.*
A. F. Ganz
Carl Schwartz

Society History

J. E. Sweet, *Chmn.*
F. R. Hutton, *Secy.*
H. H. Suplee

Flanges

H. G. Stott, *Chmn.*
A. C. Ashton
A. R. Baylis
W. M. McFarland
Wm. Schwanhausser
J. P. Sparrow

Committee on National Museum

E. D. Meier, *Chmn.*
G. F. Kunz
George Mesta
H. G. Reist
Ambrose Swasey

Code of Ethics

C. W. Baker, *Chmn.*
C. T. Main
E. D. Meier
Spencer Miller
C. R. Richards

Nominating Committee

J. R. Freeman, *Chmn.*
Chas. T. Main
Thos. Morrin
Fred. Sargent
C. C. Thomas

Standardization of Catalogues

Wm. Kent, *Chmn.*
J. R. Bibbins
M. L. Cooke
W. B. Snow

Chairmen of Sub-Committees of Committee on Increase of Membership

Boston, A. L. Williston
Buffalo, W. H. Carrier
Chicago, Fay Woodmansee
Cincinnati, J. T. Faig
Michigan, H. W. Alden
New York, J. A. Kinkead
Philadelphia, T. C. McBride
St. Louis, John Hunter
St. Paul, Max Toltz
San Francisco, Thomas Morrin
Seattle, R. M. Dyer
Troy, A. E. Cluett

Increase of Membership

I. E. Moultrop, *Chmn.*
F. H. Colvin
H. V. O. Coes
J. V. V. Colwell
R. M. Dixon
W. R. Dunn
J. P. Ilsley
E. B. Katte
R. B. Sheridan
H. Struckmann

SUB-COMMITTEES OF THE COMMITTEE ON MEETINGS

Cement Manufacture

J. G. Bergquist, *Chmn.*
H. J. Seaman, *V-Chmn.*
G. S. Brown
W. R. Dunn
F. W. Kelley
Morris Kind
F. H. Lewis
W. H. Mason
R. K. Meade
Ejnar Posselt
H. Struckmann
A. C. Tagge
P. H. Wilson

Machine Shop Practice

F. H. Colvin, *Chmn.*
E. P. Bullard
L. D. Burlingame
W. L. Clark
A. L. DeLeeuw
W. H. Diefendorf
F. L. Eberhardt
F. A. Errington
A. A. Fuller
H. D. Gordon
H. K. Hathaway
E. J. Kearney
Wm Lodge
F. E. Rogers
N. E. Zusi

Textiles

C. T. Plunkett, *Chmn.*
E. W. Thomas, *Secy.*
D. M. Bates
John Eccles
E. D. France
E. F. Greene
F. W. Hobbs
C. R. Makepeace
C. H. Manning
H. F. Mansfield

Iron and Steel

Jos. Morgan, *Chmn.*
Thos. Towne, *Secy.*
W. P. Barba
F. F. Beall
Rogers Birnie
A. L. Colby
Julian Kennedy
M. T. Lothrop
W. E. Snyder
J. T. Wallis
R. M. Watt

Depreciation and Obsolescence

Alex. C. Humphreys, *Chmn.*
J. G. Bergquist
C. J. Davidson
A. E. Forstall
F. W. Kelley
H. Struckmann

Air Machinery

F. W. O'Neil, *Chmn.*
H. V. Conrad
William Prellwitz
R. H. Rice

Administration

J. M. Dodge, *Chmn.*
L. P. Alford, *Secy.*
D. M. Bates
John Calder
H. A. Evans
James Hartness
W. B. Tardy
Alexander Taylor
H. H. Vaughan

Industrial Building

F. A. Waldron, *Chmn.*
H. A. Burnham
Charles Day
William Dalton
J. O. DeWolf
C. T. Main

Railroads

E. B. Katte, *Chmn.*
G. M. Basford
W. G. Besler
A. H. Ehle
T. N. Ely
W. F. M. Goss
A. L. Humphreys
W. F. Kiesel
W. B. Potter
N. W. Storer
H. H. Vaughan
R. V. Wright

Fire Protection

J. R. Freeman, *Chmn.*
E. V. French, *V-Chmn.*
Albert Blauvelt
F. M. Griswold
H. F. J. Porter
T. W. Ransom
I. H. Woolson

Hoisting and Conveying

R. B. Sheridan, *Chmn.*
C. K. Baldwin
Alex. C. Brown
O. G. Dale
P. J. Fickinger
F. E. Hulett
Spencer Miller
A. L. Roberts
Harry Sawyer

GEOGRAPHICAL SECTIONS OF THE SOCIETY

Milwaukee

Fred H. Dorner, *Chmn*
M. A. Beck
Arthur Simon
Henry Weickel
E. P. Worden

Cincinnati

A. L. DeLeeuw, *Chmn.*
J. T. Faig, *Secy.*
W. G. Franz
G. W. Galbraith
L. H. Thullen

St. Louis

E. L. Ohle, *Chmn.*
F. E. Bausch, *Secy.*
F. N. Jewett
John Hunter
L. C. Nordmeyer

San Francisco

A. M. Hunt, *Chmn.*
T. W. Ransom, *Secy.*
W. F. Durand
E. C. Jones
Thos. Morrin

LOCAL MEETINGS OF THE SOCIETY

Boston

Henry Bartlett, *Chmn.*
R. E. Curtis, *Secy.*
H. N. Dawes
W. G. Snow
A. L. Williston

New York

F. A. Waldron, *Chmn.*
Edward Van Winkle, *Secy.*
R. V. Wright, *Treas.*
H. R. Cobleigh
J. J. Swan

Chicago

Paul P. Bird, *Chmn.*
C. W. Naylor, *Secy.*
C. R. Birdsey
W. B. Jackson
A. W. Moseley

Philadelphia

A. C. Jackson, *Chmn.*
D. R. Yarnall, *Secy.*
J. E. Gibson
W. C. Kerr
T. C. McBride

New Haven

E. S. Cooley, *Chmn.*
E. H. Lockwood, *Secy.*
F. L. Bigelow
L. P. Breckenridge
H. B. Sargent

OFFICERS OF THE GAS POWER SECTION

Chairman

F. R. Hutton

Secretary

Geo. A. Orrok

Gas Power Executive Committee

C. H. Benjamin (1)
W. H. Blauvelt (3)
W. D. Ennis (5)
H. J. K. Freyn (1)
F. R. Low (2)
I. E. Moultrop (4)
H. H. Suplee (1)

Gas Power Literature Committee

R. B. Bloemeke, *Chmn.*
A. W. H. Griepe
W. F. Monaghan
W. S. Morrison
S. I. Oesterreicher
H. G. Wolfe

Gas Power Membership Committee

A. F. Stillman, *Chmn.*
H. V. O. Coes
J. H. Lawrence
F. S. King
J. H. Norris
G. M. S. Tait
J. D. Shaw
H. W. Anderson
C. D. Smith

Gas Power Committee on Meetings

Wm. T. Magruder, *Chmn.*
W. H. Blauvelt
E. D. Dreyfus
A. H. Goldingham
Nisbet Latta
H. B. MacFarland

OFFICERS OF AFFILIATED SOCIETY

Providence Association of Mechanical Engineers

T. M. Phetteplace, *Pres.*
J. A. Brooks, *Secy.*
W. H. Paine, *Vice-Pres.*
A. H. Whatley, *Treas.*

Note—Numbers in parentheses indicate number of years the member has yet to serve.

OFFICERS OF THE STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN	CORRESPONDING SECRETARY
Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	H. E. Erickson	A. N. Koch
Case School of Applied Science	Feb 14, 1913	F. H. Vose	H. C. Mummert	C. Stemm
Columbia University	Nov. 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen
Cornell University	Dec. 4, 1908	R. C. Carpenter	J. G. Miller	Edw. Mendenhall
Lehigh University	June 2, 1911	P.B. de Schweinitz	W. C. Owen	T. G. Shaffer
Leland Stanford Jr. Univ.	Mar. 9, 1909	W. F. Durand	C. T. Keefer	K. J. Marshall
Mass. Inst. of Tech.	Nov. 9, 1909	E. F. Miller	W. H. Treat	L. L. Downing
New York University	Nov. 9, 1909	C. E. Houghton		
Ohio State University	Jan.10, 1911	Wm. T. Magruder	R. H. Neilan	R. M. Powell
Penna. State College	Nov. 9, 1909	J. P. Jackson	H. L. Swift	H. L. Hughes
Poly. Inst. of Brooklyn	Mar. 9, 1909	W. D. Ennis	B. L. Huestis	A. Bielek
Purdue University	Mar. 9, 1909	G. A. Young	A. D. Meals	G. F. Lynde
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	E. Kneass	R. F. Fox
State Univ. of Iowa	Apr.11, 1913	R. S. Wilbur	F. H. Guldner	C. S. Thompson
State Univ. of Kentucky	Jan.10, 1911	F. P. Anderson	R. R. Taliaferro	F. J. Forsyth
Stevens Inst. of Tech.	Dec. 4, 1908	Alex.C.Humphreys	L. F. Bayer	C. H. Colvin
Syracuse University	Dec. 3, 1911	W. E. Ninde	O. W. Sanderson	R. A. Sherwood
Univ. of Arkansas	Apr.12, 1910	B. N. Wilson	M. McGill	C. Bethel
Univ. of California	Feb.13, 1912	Joseph N. LeConte	J. F. Ball	G. H. Hagar
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	A. O. Hurxthal	E. A. Oster
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	A. H. Aagaard	H. E. Austin
Univ. of Kansas	Mar. 9, 1909	F. W. Sibley	E. A. Van Houten	L. E. Knerr
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	E. H. Bigelow	O. H. Davis
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	W. P. Jesse	R. Runge
Univ. of Minnesota	May12, 1913	J. J. Flather		
Univ. of Nebraska	Dec. 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh
Univ. of Wisconsin	Nov. 9, 1909	A. G. Christie	W. K. Fitch	J. W. Griswold
Washington University	Mar.10,1911	E. L. Ohle	D. Southerland	A. Schleiffarth
Yale University	Oct.11, 1910	L. P. Breckenridge	C. E. Booth	O. D. Covell

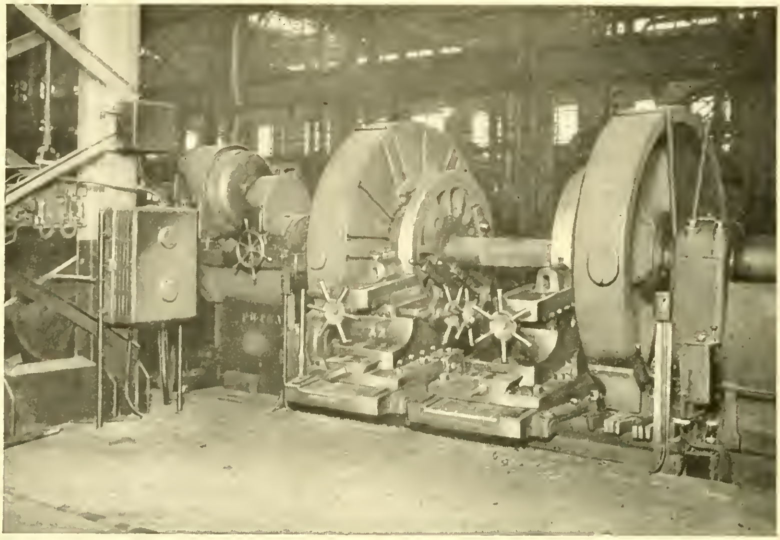
till disengaged by the operator. Arresting the feed without releasing the carriage gives the tool a chance to accurately face the shoulder, leaving a smooth surface instead of the ragged face left when carriage is released under full cut.

It has been the practice heretofore to arrange the positive stop a thirty-second of an inch beyond the knock-off for the feed, and in the usual operation of a machine of this kind the feed knocks off, and then the turret slide, released, jumps back, and the tool digs in, cutting a slight groove just back of the shoulder. When on work requiring exact shoulder distances or smoothly-finished shoulders, the operator brings the slide against the positive stop, holding it there with as nearly as possible uniform pressure until the turner has surely faced its full length. In the present machine the turret is always fed against the positive stop and held there with a uniform pressure, insuring the most accurate results for shoulder length.

Extracts from the book of the Hartness Flat Turret Lathe. Copies of the book mailed on request.

Machine Company Queen Victoria St. London, England.

France, Spain and Belgium: F. Auberty & Co., 91 Rue de Maubeuge- Paris. Italy, W. Vogel, Milan



Press a Button to Start or Stop Your Car Wheel Lathes

The G-E motor drive for car wheel lathes is controlled by push buttons located wherever desired for convenience of operator. These buttons are used to quickly start or stop the motor, the latter being accomplished by automatic electric braking.

The exact cutting speed required, for any work, at any moment, is obtained by turning the knobs on a box, in easy reach of the workman.

The convenience and responsiveness of this drive, together with the close speed adjustments instantly attainable, reduce the time required for a job and lessen the power charge.

General Electric Company

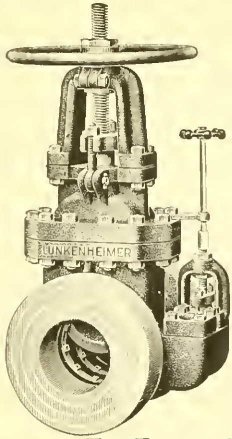
Largest Electrical Manufacturer in the World

General Office: Schenectady, N. Y.

DISTRICT OFFICES IN:

Boston, Mass.	New York, N. Y.	Philadelphia, Pa.	Atlanta, Ga.
Cincinnati, Ohio	Chicago, Ill.	Denver, Colo.	San Francisco, Cal.

SALES OFFICES IN ALL LARGE CITIES 4248



LUNKENHEIMER "VICTOR" GATE VALVES

Made in Standard, Medium, Heavy and Extra Heavy Iron Body Brass Mounted Patterns, "PUDDLED" SEMI-STEEL and CAST STEEL, with either STATIONARY STEM or OUTSIDE SCREW AND YOKE, and with or without By-pass.

The valves are double-seated, can be packed under pressure and all parts subjected to wear are renewable.

Lunkenheimer "Victor" Gate Valves are made entirely of iron for use in handling cyanides and other acids which attack brass.

SPECIFY AND INSIST upon securing genuine LUNKENHEIMER MAKE. Do not accept substitutes, —they are never as good as the genuine. Your local dealer can furnish them; if not, write us.

Write for Catalogue.

THE LUNKENHEIMER COMPANY

Largest Manufacturers of High Grade Engineering Specialties in the World

General Offices and Works, CINCINNATI, OHIO, U. S. A.

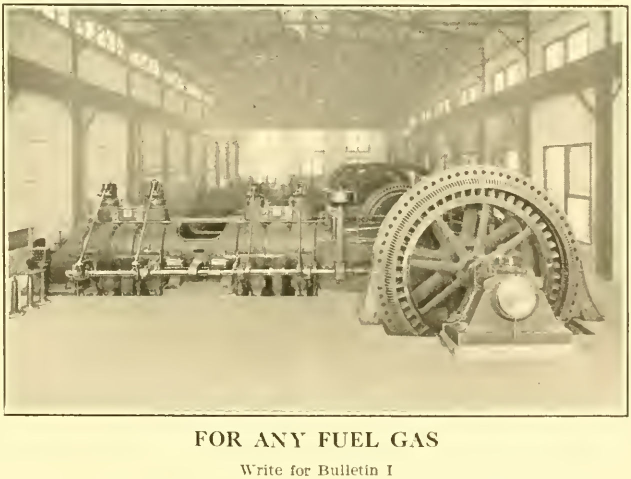
New York,	Chicago,	Boston,	London, S. E.
64-68 Fulton Street.	186 N. Dearborn Street.	138 High Street.	35 Great Dover Street

6-4

GAS ENGINES

From 500 Brake Horsepower—Upwards

RELIABLE



ECONOMICAL

FOR ANY FUEL GAS

Write for Bulletin I

MESTA MACHINE COMPANY, Pittsburgh, Pa.

FORGING PRESSES—AIR COMPRESSORS—CONDENSERS—STEEL CASTINGS

MACHINE SHOP EQUIPMENT

THE FELLOWS GEAR SHAPER CO.

SPRINGFIELD, VT.

The Gear Shaper cuts the smoothest gears in use, because the cutter is a theoretically correct generating tool and is ground after being hardened. It is also the fastest machine on the market by 25 to 50%. Literature gives reasons in detail.

GEAR SHAPERS

THE GARVIN MACHINE COMPANY

137 Varick St. NEW YORK CITY

Manufacturers of a complete line of Plain and Universal Milling Machines, Screw Machines, Monitor Lathes, Tapping Machines, Duplex Drill Lathes, Speed Lathes, Cutter Grinders, Automatic Chucks, etc.

MILLING MACHINES

THE HARTFORD SPECIAL MACHINERY CO.

HARTFORD, CONN.

Builders of High Grade, Accurate, Special Machinery, Fixtures, Jigs and Tools.

SPECIAL MACHINERY

THE HEALD MACHINE COMPANY

WORCESTER, MASS.

Manufacturers of Grinding Machines. Internal Grinders, Cylinder Grinders, Surface Grinders, Drill Grinders.

GRINDING MACHINES

INGERSOLL-RAND COMPANY

11 Broadway NEW YORK

Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

AIR COMPRESSORS

AIR TOOLS AND HOISTS

JONES & LAMSON MACHINE CO.

SPRINGFIELD, VT.

Manufacturers of the Hartness Flat Turret Lathe; made in two sizes for both bar and chuck work.

TURRET LATHES

THE KING MACHINE TOOL CO.

CINCINNATI, O.

Vertical Turret Machines, 28″ and 34″. Vertical Boring and Turning Machines, 42″ to 84″, inclusive.

HEAVY DUTY BORING MILLS

FOUNDRY EQUIPMENT

BLOWERS, FANS, DRYERS, ETC.

PAPERS PUBLISHED BY A. S. M. E.

No. 1320. Commercial Application of the Turbine Turbo-Compressors: R. H. Rice, price, $0.30; No. 830. Compression and Liquidification of Gas: A. L. Rice, price $0.10; No. 804. A Pneumatic Despatch-tube System for Rapid Transportation of Mails in Cities: B. C. Batcheller, price $0.30; No. 1295. The Development of the Air Brake: (Presidential Address) G. Westinghouse, price $0.20.

PAPERS ON AIR COMPRESSORS AND PNEUMATIC TOOLS

ROLLING MILL MACHINERY

PAPERS ON ROLLING MILL MACHINERY

PAPERS PUBLISHED BY A. S. M. E.

No. 868. Some Landmarks in the History of the Rolling Mill: C. H. Morgan, price \$0.20; No. 1319. Pressure Recording Indicator for Punching Machinery: C. C. Anthony, price \$0.10; No. 1322. Power Forging, with special Reference to Steam Hydraulic Forging Presses: B. Gerdau and G. Mesta, price \$0.10.

PUMPS AND HYDRAULIC TURBINES

PAPERS ON PUMPS AND HYDRAULIC TURBINES

PAPERS PUBLISHED BY A. S. M. E.

No. 381. Standard Method of Conducting Duty Trials of Pumping Engines: Committee Report, price \$0.30; No. 1144. Balancing of Pumping Engines: A. S. Nagle, price \$0.10; No. 1110. Development of Water-wheel Governor: M. A. Replogle, price \$0.20; No. 1113. Turbine Design as Modified for Close Regulation: G. A. Bovinger, price \$0.10.

STEAM ENGINES AND BOILERS

PAPERS ON STEAM ENGINES AND BOILERS

PAPERS PUBLISHED BY A. S. M. E.

No. 1081. Counter Weights for Large Engines: D. S. Jacobus, price $0.20; No. 1329. Strain Measurements of Some Steam Boilers under Hydrostatic Pressure: J. E. Howard, price $0.30; No. 1298. Combustion and Boiler Efficiency: E. A. Uehling, price $0.30; No. 1308. Oil Fuel for Steam Boilers: B. R. T. Collins, price $0.20.

PAPERS ON POWER PLANT SPECIALTIES

PAPERS PUBLISHED BY A. S. M. E.

No. 1288. Improved Absorption Dynamometer: C. M. Garland, price $0.10; No. 1287. Experimental Analysis of a Friction Clutch Coupling: W. T. Magruder, price $0.20; No. S 43 X. Automatic Control of Condensing Water: B. Viola, price $0.10; No. S 26 X. Air Leakage in Steam Condensers: T. C. McBride, price $0.20.

HOISTING AND CONVEYING MACHINERY

AIR COMPRESSORS AND PNEUMATIC TOOLS

ELECTRICAL APPARATUS

POWER TRANSMISSION

ENGINEERING MISCELLANY

PAPERS PUBLISHED BY A. S. M. E.

No. 1230. Transmission of Power by Leather Belting: C. G. Barth, price $0.50; No. 1313. Milling Cutters and their Efficiency: A. L. DeLeeuw, price $0.30; No. 1083 Belt Creep: W. W. Bird, price $0.10; No. 1291. Symposium on High Speed Tools: H. I. Brackenbury, and Discussion, price $0.70.

PAPERS ON MACHINE SHOP PRACTICE

BALL BEARINGS

ENGINEERING SCHOOLS and COLLEGES

PROFESSIONAL CARDS

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

NOVEMBER 1913

35 CENTS A COPY $3 A YEAR

ANNUAL MEETING: DECEMBER 2-5. MONTHLY MEETINGS: NEW YORK, NOVEMBER 11; BOSTON, NOVEMBER 19; CHICAGO, NOVEMBER 19; PHILADELPHIA, NOVEMBER 19; CINCINNATI, NOVEMBER 20; NEW HAVEN, NOVEMBER 21

WHY YOU SHOULD ATTEND THE ANNUAL MEETING

Membership in The American Society of Mechanical Engineers affords the privilege of engaging in the broad work of the advancement of the engineering profession, as well as the distinct advantage of the personal benefits accruing from such affiliation. The development of acquaintanceships at the meetings and the mutual interchange of information are also of value.

The 1913 Annual Meeting will be held December 2–5 inclusive and its program embraces a variety of subjects of importance to the numerous industries of the country (see page 4).

Your attention is called to the excellent opportunity afforded by the Annual Meeting to extend the hospitality of the Society to your professional associates and acquaintances and incidentally secure their interest in applying for membership.

Upon request invitations will be sent.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

H. V. O. Coes	R. M. Dixon	E. B. Katte
F. H. Colvin	W. R. Dunn	R. B. Sheridan
J. V. V. Colwell	J. P. Ilsley	H. Struckmann

Chairmen of Sub-Committees

Atlanta, P. A. Dallas
Boston, A. L. Williston
Buffalo, W. H. Carrier
Chicago, Fay Woodmansee
Cincinnati, J. T. Faig
Cleveland, R. B. Sheridan
Michigan, H. W. Alden
New York, J. A. Kinkead
Philadelphia, T. C. McBride
St. Louis, John Hunter
St. Paul, Max Toltz
San Francisco, Thos. Morrin
Seattle, R. M. Dyer
Troy, A. E. Cluett

NOVEMBER 1913 VOL. 35 No. 11

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

CONTENTS

The Journal is published monthly by The American Society of Mechanical Engineers.
Price, 25 cents a copy, or $2 a year, to members and affiliates of the Society; 35 cents a copy or $3 a year to all others. Postage to Canada, 50 cents additional; to foreign countries, $1 additional.
Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

COMING MEETINGS OF THE SOCIETY

November 11, *New York City*, Engineering Societies Building. Paper: A New Centrifugal Pump with Helicoidal Impeller, C. V. Kerr.

November 19, *Boston, Mass.*, joint meeting under auspices of Boston Section of Civil Engineers. Paper: Engineering Lessons from the Ohio Floods, John W. Alvord.

November 19, *Chicago, Ill.* Subject: The Iron and Steel Industry of the Chicago District. Paper by Wm. A. Field, and discussion by other prominent men.

November 19, *Philadelphia, Pa.*, joint meeting with Franklin Institute. Paper: Producer Gas from Low-Grade Fuels, R. H. Fernald.

November 20, *Cincinnati, Ohio.* Paper: Stellite, by Elwood Haynes.

November 21, *New Haven, Conn.*, Mason Laboratory, Sheffield Scientific School. Afternoon and evening sessions. See page 7 for program.

December 2–5, *Annual Meeting*, Engineering Societies Building, New York. See page 4 for program.

// THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 NOVEMBER, 1913 NUMBER 11

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 NOVEMBER, 1913 NUMBER 11

ANNUAL MEETING

Plans are now practically complete for the coming Annual Meeting and the program is published herewith in its final form in so far as the arrangement of the sessions and of the social events is concerned, there remaining only the titles of a few papers not in hand at the time of its preparation, to be announced later.

It is seldom that a meeting of the Society has been arranged with so wide a diversity of subjects to be discussed. There will be two general sessions, one on Power Plant subjects, and one comprising various papers which have been prepared on investigations and tests of apparatus of different types. There will then be several sessions devoted to special interests. One of these is a Railroad Session on Steel Freight Cars, with two strong papers; another on subjects relating to Textile Manufacture, covering the general field of Mill Engineering; another on Fire Protection supplementing the one held at Baltimore last Spring, the papers relating to certain important engineering questions that enter into fire protection, while those read at Baltimore dealt with conflagrations and other larger aspects of the subject. There will also be a meeting with Gas Power papers.

The feature of the evening events will be the presentation of the Grashof Medal, which was conferred upon George Westinghouse by the Verein deutscher Ingenieure at Leipzig. This will be followed by a lecture on Leonardo da Vinci by John W. Lieb, Jr., based upon his remarkable collection of manuscripts, drawings and books relating to the life and work of this distinguished engineer and artist.

On Thursday evening there will be a German Dinner, which it is expected will be largely attended, at which those who were unable to participate in the trip will have the pleasure of hearing accounts of many of the remarkable events retold. The dinner will be followed by a dance and there will be an opportunity for those not desiring to participate in the dinner to take part in the dancing.

It is probable that in addition to the usual excursions provided around New York, there will also be one or two to points of interest outside the city. Thursday and Friday afternoons are left entirely free for excursions.

PROGRAM

Tuesday Evening, December 2

Presidential Address, followed by Reception.

Wednesday Morning, December 3

Business Meeting, followed by Professional Session, with the following papers:

Notes on the Further Operation of Large Boilers of the Detroit Edison Company, J. W. Parker

On Setting Tasks for Firemen and Maintaining High Efficiency in Boiler Plants, Walter N. Polakov

Properties of Steam, R. C. H. Heck

Wednesday Afternoon

RAILROAD SESSION

(Papers contributed by Sub-Committee on Railroads)

Steel Underframe Box Cars, G. W. Rink

Steel Frame Box Cars, R. W. Burnett

Wednesday Evening

Presentation of the Grashof Medal by the Verein deutscher Ingenieure to George Westinghouse, Past-President and Honorary Member, The American Society of Mechanical Engineers.

Address, illustrated by lantern views, on Leonardo da Vinci—Engineer and Artist, by John W. Lieb, Jr., Past-President American Institute of Electrical Engineers, and Past Vice-President, The American Society of Mechanical Engineers

Thursday Morning, December 4

PROFESSIONAL SESSION

Efficiency of Rope Driving as a Means of Power Transmission, E. H. Ahara

Comparative Tests of Lineshaft Bearings, Carl C. Thomas, E. R. Maurer and L. E. Kelso

Pitot Tubes for Gas Measurement, W. C. Rowse

Tests of Vacuum Cleaning Systems, J. R. McColl

Tests upon the Transmission of Heat in Vacuum Evaporators, E. W. Kerr.

The Art of Enameling, or the Coating of Steel and Iron with Glass, Raymond F. Nailler

SIMULTANEOUS SESSIONS

CEMENT SESSION

There will be an opportunity for those interested in Cement Manufacture, to gather for an informal discussion of various topics.

MACHINE SHOP PRACTICE

(Papers contributed by Sub-Committee on Machine Shop Practice)

Continuous Manufacturing by Placing Machines in Accordance with Sequence of Operations, Oscar F. Bornholt

Gears for Machine-Tool Drives, John Parker

Cast-Iron for Machine-Tool Parts, Henry M. Wood

A Record of Pressed Fits, C. F. MacGill

TEXTILES

It is expected that papers will be contributed by the Sub-Committee on Textiles, on Cotton Conveying Systems, Specifications for Factory Timbers, Costkeeping in Textile Mills, and The Use of Sprinkler Systems for Heating in Textile Mills.

GAS POWER

(Paper contributed by the Gas Power Section)

A New Process for Cleaning Producer Gas, H. F. Smith

Other papers are expected on the subject of the Diesel Engine

Thursday Afternoon

Excursions to points of interest in New York and vicinity.

Thursday Evening

German Dinner, reproducing one of the menus from the trip abroad. This will not only be a reunion of those who went on the trip, but is being arranged with a view to giving those who were unable to participate some idea of the many interesting events which the American guests enjoyed. Addresses on the German trip will be made, illustrated by slides.

A Dance will follow the dinner.

Friday Morning, December 5

Announcement of Tellers of Election and presentation of the President-Elect. This will be followed by a session on

FIRE PROTECTION

(Papers contributed by the Sub-Committee on Fire Protection)

The Fire Hazard in Turbo-Generators, G. S. Lawler
Extinguishing Fires in Oils and Volatile Liquids, Edw. A. Barrier
Control of Automatic Sprinkler Valves, Fred J. Miller

Other papers are expected on Installations for Handling Fuel Oil, Gasolene, Etc.; Features of Construction of Fire Pumps; and The Design and Construction of Elevated Tanks

Friday Evening

COLLEGE REUNIONS

It has been the custom for the alumni of certain of the technical schools to hold reunions in New York at about this time of the year, and an opportunity will be offered for such gatherings on this evening.

The alumni of Stevens Institute of Technology are arranging for a theater party, in which the Society and their friends are invited to take part. Supper and informal dancing at the Hotel Astor will follow. Information regarding tickets, etc., may be obtained from Mr. R. K. MacMaster, at the Society's rooms.

Worcester Polytechnic Institute will hold its annual dinner at the Hotel Astor, and it is hoped that as many members of the Society as possible will participate. Notice of such intention and any inquiries regarding details should be sent to Mr. F. O. Price, Pratt Institute, Brooklyn.

The Polytechnic Institute of Brooklyn will give a reunion dance in the rooms of the Society. Those desiring to attend are requested to communicate with Prof. W. D. Ennis at the Institute.

A dinner of the Alumni of Yale University will be held at the Yale Club of New York. All graduates of Yale are invited to attend, and to communicate with Mr. Bradley Stoughton, 25 W. 39th St., Secy., A. I. M. E., New York.

RAILROAD TRANSPORTATION AND HOTELS

There will be no special railroad rates for the Annual Meeting this year. Those who expect to attend are urged to make early arrangements for hotel accommodations which must, as usual, be made individually.

EXHIBITION OF SAFETY APPLIANCES

The attention of the members who will attend the Annual Meeting is called to the International Exposition of Safety and Sanitation which will be held under the auspices of the American Museum of Safety in the New Grand Central Palace, New York, from December 11 to 20. It is expected that the exposition will represent the progress in America of safety and sanitation, covering accident prevention, industrial, city, home and social hygiene, and mutuality enterprises. This will be the first comprehensive exposition of this nature

ever held in America and by special act of Congress the foreign exhibits will be admitted free of duty.

NEW HAVEN MEETING

The date of the meeting in New Haven has been changed from November 19, to Friday, November 21, and will as previously announced be held in the Mason Laboratory of the Sheffield Scientific School, Yale University. The program is as follows:

Afternoon Session, 3.00 *to* 5.00 *p.m.*

E. S. Cooley, *Chairman*

Topic: Coöperative Industrial Research

Coöperative Industrial Research at the Sheffield Scientific School with Connecticut Manufacturers, by L. P. Breckenridge, professor of mechanical engineering, Yale University.

A Central Bureau for Industrial Research, by Linn Bradley, of the Research Corporation of New York.

Research Work of the Bureau of Mines, by O. P. Hood, chief mechanical engineer of the United States Bureau of Mines.

Coöperation of State and University for Industrial Research, by a representative of the engineering experiment station of the University of Illinois.

History of the Manufacture of Brass, by W. B. Edwards, Ansonia, Conn.

Intermission and Dinner, 5.00 *to* 7.30 *p.m.*

The new laboratory of electrical engineering and the Mason laboratory will be open for inspection.

Dinner will be served at the Yale dining hall at 6.00 p.m. and all visitors will be welcome at this social part of the meeting. Price, fifty cents.

Evening Session, 7.30 *to* 9.30 *p.m.*

Safety Devices used in Connection with Grinding Wheels, by R. G. Williams of the Norton Company, Worcester, Mass.

Experiments with Residence Heating Boilers at the Mason Laboratory, by D. B. Prentice of New Haven.

Motor Car Testing, by E. H. Lockwood, assistant professor of mechanical engineering, Yale University, with demonstration of automobile testing apparatus in the laboratory.

COMING MEETINGS IN LOCAL CENTERS

The Chicago Section is now entering upon its second year, with plans for increased activity. During the past year five meetings have been held, with an average attendance of over sixty, and it is believed that this number will be considerably exceeded the coming year.

The Chicago membership take a great deal of satisfaction in the

fact that Dr. Goss, the President of the Society, is now located in Chicago, having obtained a year's leave of absence from the University of Illinois in order to act as chief engineer for the Chicago Association of Commerce committee on smoke abatement and the electrification of railway terminals.

It is proposed to hold four meetings during the coming season, the first of which is scheduled for Wednesday, November 19. In connection with each of these meetings there will be a dinner, the entire meeting taking place in the dining room, thus making possible informal discussion. The subjects to be discussed are as follows: First meeting, the iron and steel industry of the Chicago district; second meeting, steam power plants; third meeting, internal-combustion engines; fourth meeting, refrigeration. At the November meeting, Wm. A. Field, general superintendent of the Illinois Steel Company's plant at South Chicago, who has been one of the prominent figures in the development of this industry, will be the principal speaker, and there will be discussion by other prominent men. The Secretary of the Chicago Section is Mr. Paul P. Bird, 120 West Adams Street, Chicago, from whom further information can be obtained.

PHILADELPHIA MEETINGS

In Philadelphia there will be a joint meeting with the Franklin Institute on November 19, with a paper on the subject of Producer Gas from Low-Grade Fuels, by Prof. R. H. Fernald. On December 9 it is planned to hold a symposium on how far shall judgment be exercised in the interpretation of engineering specifications, with several short papers from prominent men. In January and February joint meetings will be held, the first with the Engineers Club, with a paper on Some Recent Improvements in Steam Locomotives, by George R. Henderson, and the second with the American Institute of Electrical Engineers, on Business Training for the Engineer, with discussion by Dr. Alex. C. Humphreys, Theodore I. Jones and Ralph D. Mershon. The March meeting will probably be devoted to the subject of Recent Developments in Turbine-Driven Centrifugal Blowers, the author of the paper being as yet unannounced.

BOSTON MEETINGS

Boston members also have their plans for the coming season well under way. On November 19 there will be a joint meeting of the representatives of the various engineering societies having members in Boston, under the auspices of the Boston Society of Civil Engineers,

at which a paper on Engineering Lessons from the Ohio Floods will be presented by John W. Alvord of Chicago. The December meeting will be under the auspices of the Boston Section of the American Institute of Electrical Engineers, while our Society will be responsible for the January meeting, and in February the annual dinner will be held.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. The Membership Committee and in turn the Council urge the members to assume their share of responsibility in receiving into membership these candidates by advising the Secretary promptly of any candidate whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before December 10, 1913:

Abbott, Henry W., Asst. to Master Mech., The Penna. Steel Co., Steelton, Pa.
Ackerman, Geo. E., Member of Firm, Jacobson & Ackerman, Grand Rapids, Mich.
Allen, Percy J., Member of Firm, American & Brasilian Engrg. Co., Curityba, Brazil.
Armes, Wm. A., Supt. & Res. Engr., F. W. Bird & Son, Pont Rouge, P. Q., Canada.
Armstrong, Geo. S., Engr., Suffern & Son, London, Eng.
Ayars, Wm. Stewart, Prof. of M.E. & E.E., Nova Scotia Tech. Coll., Halifax, N. S.
Belcher, Thos. H., Engr. & Rep., The Black-Clawson Co., Hamilton, Ohio.
Berge, Geo. H., Sales Mgr., Illinois Stoker Co., Chicago, Ill.
Bidwell, Carlyle D., Mech. Engr., International Harvester Corp., Akron, Ohio.
Blumenfeld, Ralph, 241 West 108th St., New York.
Bristol, Howard H., The Bristol Co., Waterbury, Conn.
Brown, Eugene L., Jr., Ch. Deputy Insp. of Boilers, Elev. & Smoke Abatement, St. Louis, Mo.
Carroll, John T., Asst. Genl. Supt., M.P., B. & O. RR., Baltimore, Md.
Cassidy, Perry R., Instr. in Steam Engrg., State Univ. of Ky., Lexington, Ky.
Clouser, Geo. L., Special Apprentice, P. & R. R.R., Reading, Pa.
Douglas, Morris D., Mech. Engr., Exp. Dept., Penna. Steel Co., Steelton, Pa.
Eastwood, Sidney K., Draftsman, Day & Zimmerman, Philadelphia, Pa.
Ellingham, Robt. W., Works Mgr., Hendee Mfg. Co., Springfield, Mass.
Evans, Wm. A., New England Mgr., Griscom-Russell Co., Boston, Mass.
Foote, Geo. W., Salesman with Jacob Mazer, Acoustical Engr., Pittsburgh, Pa.
Frölich, Fr., Secy. of Asso'n of German Machine Shops, Düsseldorf, Germany.
Fuller, John, Genl. Mgr., Conveying Machinery Co., New York.
Gerber, Samuel R., Task-setter, Remington Typewriter Co., Ilion, N. Y.
Giller, Frederick S., Asst. Plant Engr., Western Elec. Co., London, Eng.
Glynn, Frank L., Director, Trade Education in Public Schools, New Haven, Conn.
Hagadorn, Thos. H. X., Draftsman, Arkansas Valley Smelter, Leadville, Colo. (Committee solicits references.)
Hamilton, Chester B., Jr., Mgr., Hamilton Gear & Mch. Co., Toronto, Canada.
Hanscom, Wm. W., Cons. Engr., San Francisco, Cal.
Helmreich, L. W., Head of Dept. of Elec., Ranken Mech. School, St. Louis, Mo.
Hemstrought, Harry B., Mech. Draftsman, Crowell-Sherman-Stalter Co., Genl. Contrs., Lyons N. Y.
Howells, Frank E., Supt. of Shops, The Penna. Steel Co., Steelton, Pa.

Kaighn, Herbert E., Ballistic Engr., E. I. DuPont Powder Co., Experimental Sta., Henry Clay P. O., Del.

Lekberg, Carl H., Asst. Prof. of M.E., Univ. of Maine, Orono, Me.

Linley, Fred. H., Cor. Engr., Steam Turbine Dept., Allis-Chalmers Mfg. Co., W. Allis, Wis.

Little, James E., Mech. Engr., The Spanish-American Iron Co., Steelton, Pa.

Lynch, Francis J., Mech. Supt., Peerless Tube Co., New York.

McKaig, W. Wallace, Genl. Mgr., The McKaig Mch., Fdy. & Supply Wks., Cumberland, Md. (Committee solicits references.)

Maurhoff, Presley A. L., Rep. & Engr., Standard Plunger Elevator Co., New York.

Murphy, Geo. F., Sales Rep., Busch-Sulzer Bros.-Diesel Eng. Co., St. Louis, Mo.

Oberg, Erik V., Associate Editor, Machinery, New York.

Ortner, Louis, Fuel Expert, Dept. Water, Gas & Elec., The City of New York.

Perry, Edward D., Mech. Engr., A. L. Ide & Sons, Springfield, Ill.

Phillips, Jackson C., Engrg. Dept., Revere Rubber Co., Providence, R. I.

Reddig, Wm. H., Genl. Supt., Motor Mfg., Continental Motor Mfg. Co., Detroit, Mich.

Rickcord, Reginald V. G., Mech. D'ftsman, Cluett, Peabody & Co., Inc., Troy, N. Y.

Rollins, Henry M., Supt., Gulfport Creosoting Co., Gulfport, Miss.

Schaeffer, Simon S., Ch. Mech. Engr., Thompson-Starrett Co., New York.

Scott, James, Cons. Sugar Engr., Pacific Commercial Co., Manila, P. I.

Seiler, Paul, Ch. Engr., Pacific Rolling Mill Co., San Francisco, Cal.

Sloan, Ben, Salesman, Pratt & Whitney Co., New York.

Small, Frank W., Steam Dept., Pacific Gas & Elec. Co., San Francisco, Cal.

Sullivan, John L., Asst. Foreman, Westinghouse E. & M. Co., E. Pittsburgh, Pa.

Waddell, Jos. A., Jr., Genl. Supt., Spencer Heater Co., Scranton, Pa.

Webb, Wilfred LeP., Director & Ch. Engr., Crossley Bros., Ltd., Otto Gas Engine Works, Manchester, England.

Weber, Herman R., Ch. Engr. & Genl. Mgr., The Palmer Forced Draft Slack Burner Co., Fort Scott, Kan.

Wendle, Geo. E., Asst. Genl. Mgr., Lycoming Edison & W'msport Pass. Ry. Cos., Williamsport, Pa.

Williams, Irving, Salesman, Brown & Sharpe Mfg. Co., Providence, R. I.

Woodworth, Joseph V., Cons. Engr. & Mfgrs. Rep., Worcester Pressed Steel Co., Worcester, Mass.

Zipf, John, 1525 Fulton St., San Francisco, Cal.

PROMOTION FROM ASSOCIATE

Anderson, Leslie D., Supt., U. S. Smelting Co., Midvale, Utah.

PROMOTION FROM JUNIOR

Bradshaw, Grant D., Steam Engr., Cambria Steel Co., Johnstown, Pa.

Connolly, Jas. H., Mech. Engr., The Taft-Peirce Mfg. Co., Woonsocket, R. I.

Cook, Wm. P., Jr., Asst. to Ch. Mech. Engr., Thompson-Starrett Co., New York.

Durant, Aldrich, Engr. in charge & Agent, MacArthur, Perks & Co., Ltd., and MacArthur Bros., Havana, Cuba.

Snodgrass, John M., Asst. Prof. of Ry. Engrg., Univ. of Ill., Urbana, Ill.

Tallmadge, Webster, Master Mechanic, Norwood Mill, Bird & Son, E. Walpole, Mass.

Torrance, Chas. E., Jr., Mech. Engr., Norwood Engrg. Co., Northampton, Mass.

SUMMARY

New applications	59
Promotion from Associate	1
Promotion from Junior	7
Total	67

REPORT OF THE GERMAN MEETING COMMITTEE

At the meeting of the Council on October 14, the following report was presented by the committee having in charge the arrangements for the trip to Germany:

To the President and Council:

As Chairman of the Committee of Arrangements for the Joint Meeting with the Verein deutscher Ingenieure Leipzig 1913, I beg to report as follows:

This Committee began its activities with the general circular of August 27, 1912, followed by twelve other circulars and eleven postal cards giving full particulars of the program and itinerary. After careful search among available steamers, the great steam yacht Victoria Luise, 17,000 tons, of the Hamburg-American Line, was selected, and the travel bureau of this same line chosen to make all arrangements for the land trip of twenty days. As the steamer could carry about 600 passengers our right of choice of rooms was limited to March 1, 1913, but later extended a short period. By February 19, 209 had registered in the official party for the land tour in Germany, and we were informed that our final limit was fixed at 200 engineers and 100 ladies, as neither the special trains nor the hotels in Germany could take more than 300 in all. From the official lists there were 303 scheduled to sail on the steamer and 42 to join the party at Hamburg, a total of 345; but on leaving Hamburg June 22, an actual count showed 303 on the train. There were 226 passengers not of our party on the sailing list. Owing to my long and repeated absences from New York most of the preliminary work was done by the other members of the Committee under the able and untiring leadership of Mr. J. W. Lieb, Jr., the Vice-Chairman.

We sailed from Hoboken at 10:10 a.m. on Wednesday, June 10, 1913. Secretary Rice and I were the only members of the original committee on board. Under authority given me by the Council I increased the committee to 17, making with the Secretary and his assistant 19 in all, as follows:

EXECUTIVE COMMITTEE

E. D. Meier, *Chairman*
J. R. Freeman, *Vice-Chairman*
W. R. Warner, *Vice-Chairman*
James Hartness
Jesse M. Smith

COMMITTEE ON SPEAKERS

H. L. Gantt, *Chairman*
H. G. Reist, *Vice-Chairman*
Jesse M. Smith
L. W. Nelson
E. E. Keller

COMMITTEE ON EXCURSIONS

J. G. Brill, *Chairman*
A. M. Greene, *Vice-Chairman*
L. P. Breckenridge
H. M. Leland
E. E. Keller

COMMITTEE ON RESOLUTIONS

Sen. Newell Sanders, *Chairman*
F. R. Low, *Vice-Chairman*
H. M. Leland
F. G. Kretschmer
Wm. A. Doble

The Committees on Entertainment, Acquaintanceship and Fourth of July celebration had been appointed some time before and were already at work. The Entertainment Committee led by Prof. and Mrs. A. M. Greene, Jr., had provided 19 principal events, leaving no time for such diversions as sacrifices to Neptune even if the weather had suggested them.

But the steamer was steady and the sea smooth so that the entire program was enjoyable. The 226 other passengers were invited to join in our exercises, by individual invitations sent to their cabins. They entered into the spirit of the occasion with alacrity and at the close of the trip thanked us in a poem posted on the bulletin board, signed by all individually. On June 15 the captain gave a special dinner in honor of the twenty-fifth anniversary of the accession to the throne of Emperor William the Second at which our congratulatory address was read. This was responded to by a German orator with much feeling. The resolutions were sent to Berlin by aerogram the next morning.

On our arrival at Plymouth at 5 o'clock in the morning of June 18, Professor Matschoss, representing the Verein deutscher Ingenieure, and Engineer Kroebel, president, and Director Molsen and Professor Frasch, members, of the Hamburg branch of the V. D. I., came aboard to welcome us to Europe, and three officials of the Hamburg-American Travel Bureau opened an office on board to issue all the necessary circulars and tickets to the entire party. After breakfast President Kroebel delivered his address of welcome in such fervent and ardent German that its spirit was fully understood by all in our party and a cordial friendship created which thenceforth grew with every new committee we met, and they were many. These were: (1) The

council of the V. D. I., of members; (2) the honorary reception committee, 52 members; (3) eight local reception and entertainment committees, 329 members.

While naturally many of these were members of several committees, they included not less than 300 men prominent in government, manufacturing, railways and various branches of engineering, and as such they bore to our visiting party the welcome of the Verein of more than 24,000 engineers, of the vast and varied industries of Germany, of ten municipalities, of six sovereign states, and of the great German Empire.

It appears that when the V. D. I. had received our acceptance of its invitation a large number of its forty-eight branch societies applied for the privilege of receiving and entertaining us. With just regard to the time and strength of our party, the Council finally selected eight local branches; no sooner was this done than the ten cities covered by these branches demanded their right to participate in the welcome. Forty-six excursions to prominent engineering works and industrial concerns were arranged, explanatory lectures prepared, the transportation and commissariat arranged, and all with that German thoroughness and forethought that made it possible to enjoy everything with the greatest benefit and least fatigue.

The principal events were of course the two official joint meetings with the V. D. I. at Leipzig. The first, on June 23, after the official welcome, was devoted to two papers: one by Privy Councillor Lamprecht, on The Technic and Culture of the Present Day; the second, by Dr. W. F. M. Goss, President Am. Soc. M. E., on Foundations of American Engineering. Both treated their subjects in a broad and thorough manner, and it was instructive and gratifying to hear how the conclusions reached testified to the solidarity of engineering thought in the two great nations.

The King of Saxony with a brilliant court was an attentive listener for a full hour and was duly promoted to Doctor of Engineering. Our honored past-president, George Westinghouse, was unanimously voted the gold Grashof medal for his contributions to engineering science. President von Miller presented an artistic plaque to our Society commemorative of the occasion.

The second meeting, on June 24, was devoted to industrial efficiency. The subject was introduced by a comprehensive

paper by James M. Dodge, Past-President, followed by an equally thoughtful one by Professor Schlesinger of the Technical University of Charlottenburg. An interesting and warm discussion followed in which the original, scientific and humanitarian work of our Past-President Taylor was duly acknowledged as fundamental and leading. The itinerary of our trip has been fully published. Having our special train always at our disposal and the professional promptness of our party harmonizing with the perfect arrangements of the travel bureau, we were able to carry out the program as published in advance, although it included in addition to the study of the plants freely opened for our inspection, our grateful acceptance of many social functions artistically arranged and gracefully tendered, numbering no less than fifteen formal banquets and receptions, fourteen luncheons and collations, twelve concerts, lectures and special performances, and ten excursions by rail and boat. In all of these there were present some 200 or more of our German hosts. In several we had occasion to admire the democratic attitude of German officialdom at social functions. Thus, the welcome to Berlin in a carefully prepared speech by a high official of the imperial ministry of the interior, the polite comradeship of Prince William of Saxe-Weimar at Heidelberg, the visit of the aged Prince Regent Ludwig of Bavaria to our excursion steamer on Lake Starnberg in the pouring rain, with an hour's friendly chat on canals, and the uniform urbanity of the lord mayors of the cities visited.

The social functions had their own distinctive features in each city. There was manifest an amicable rivalry in giving us the best they could devise, especially as suggested by some local or historical fact, and worked out with the aid of good home talent in the arts employed. To mention any of these without a full description in this short report would savor of want of appreciation of the beauty and meaning of the performances. Full details are available in the letters, printed records, and photographs in the hands of the Secretary and will be embodied in the book being prepared at the demand of the official party.

It is my pleasant duty to record the conscientious and telling labors of our various committees which so thoroughly coördinated the events that there was not the slightest hitch anywhere. The value of this was brought home to me by the Consul General of the United States in Berlin, when I called on him some

weeks later. He said that during the past twelve months, two large American parties visiting Germany had inadvertently given serious offense by some omission, but that he had received from various cities and officials such gratifying reports of our party that these incidents were now forgotten and the American engineers accepted as the true representatives of our people.

Praise is due also to a group of graduates and undergraduates of several of our technical colleges for their untiring work as messengers on our trains and in hotels in distributing papers and packages, calling meetings and giving information.

We were all deeply impressed by these facts concerning our German hosts: That they believe laws are made to be obeyed, and though they are not blessed with such myriads of laws as we, those they have they respect; that the discipline learned in school and away has built up an industrial prowess capable of even greater conquests than those of the present: that the builders of the great empire desire peace to enable them to continue the beneficent battle compelling all natural force to the service of man; that nowhere has the engineer won a higher social standing than is accorded him in Germany; and that his ethical sense and ideals are the san e in all countries and on fully as high a level as those of the older professions.

Respectfully submitted,

E. D. Meier, *Chairman*.

A NEW PROCESS OF CLEANING PRODUCER GAS

By H. F. Smith

ABSTRACT OF PAPER

The gas to be cleaned is first cooled sufficiently to condense the tar vapors and is then passed under pressure through a porous diaphragm of spun glass. Both gas and tar pass through the diaphragm, but in passing the diaphragm the tar particles coalesce into large drops which cannot be carried along with the gas current. Any desired degree of gas cleanness can be secured. Water or other washing fluid is not required. The process is not one of filtration. A theory is advanced to explain the observed results.

A NEW PROCESS OF CLEANING PRODUCER GAS

By H. F. Smith, Lexington, Ohio

Member of the Society

In 1902 the writer instituted a series of investigations to determine the nature of the mechanical impurities present in producer gas from bituminous coal with a view to devising more effective methods for their removal. These investigations have since been continued and have resulted in the development of a commercial apparatus involving some new and interesting principles.

2 The tar and other mechanical impurities present in raw bituminous producer gas are in an extreme state of subdivision. The number of particles present is so great and the quantity of gas to be handled in commercial plants so large that the problem presents more than ordinary difficulties. The effectiveness of the ordinary types of mechanical gas washers and purifiers leaves much to be desired. The primary object has accordingly been to produce equipment that will be capable of yielding gas of a higher degree of cleanness than obtainable by ordinary methods. The apparatus in its present stage of development can be readily understood from Fig. 1.

3 The raw producer gas on leaving the producer is first cooled to a point where the tar vapors are condensed by being passed through a primary cooler or condenser. From this the gas is carried into an ordinary rotary gas pump B which delivers the gas under pressure into the main C; it is then delivered through a porous diaphragm E and discharged from there into the main F. A sump or separator G is provided in which the tar accumulates.

4 The structure of the diaphragm E is a matter of considerable importance for the successful carrying out of this process

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

and the materials used seem to have an important bearing on the operation of the equipment. The diaphragm must be sufficiently porous to permit the gas and tar to pass freely, otherwise it will soon become blocked with deposits from the gas and fail to operate. Many materials may be used for this purpose, but at present spun glass is preferred. The glass fibers are not only entirely unaltered by chemical action but seem to possess

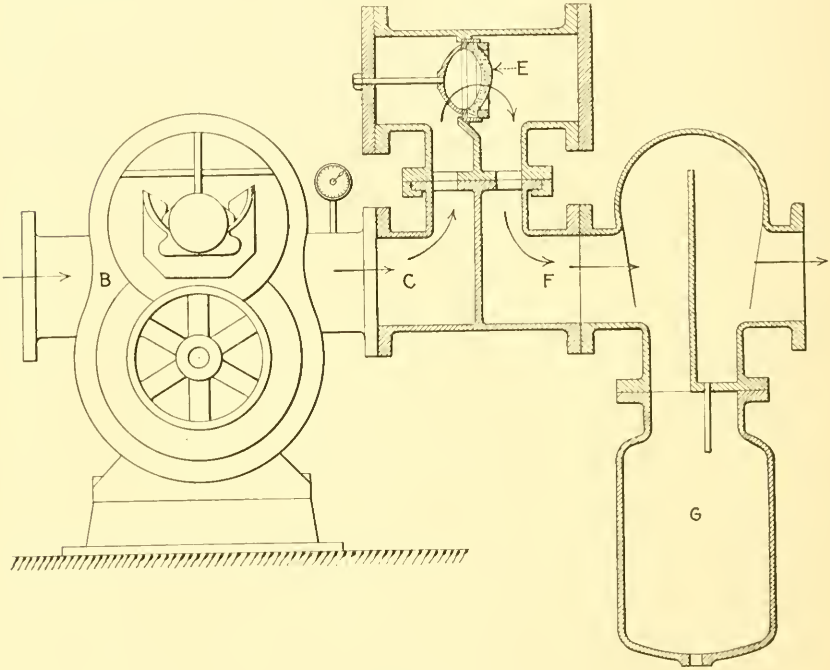


Fig. 1 Static Scrubber Layout

the necessary physical properties for the successful carrying on of this process. The spun glass in the form of ordinary glass wool (which should be carefully distinguished from slag wool, as the latter is not practicable for this purpose) is built into the form of a uniform diaphragm and is retained between two metal screens. The density of the diaphragm can be regulated by the quantity of glass used and by the degree of compression maintained between the metal screens. Ordinarily, this diaphragm is made up to a thickness of approximately one-quarter of an inch. The diameter of the diaphragm must be adjusted in accordance with the quantity of gas to be treated. Ordinarily, about 400 cu. ft. per hr. can be handled for each square inch

of diaphragm area. No tar is retained in the diaphragm, both tar and gas being discharged together.

5 In passing the diaphragm an important change in the physical state of the tar occurs. On the entering side the tar exists in a large number of minute particles, ordinarily known as tar fog. In passing the diaphragm these particles are caused to coalesce so that on the discharge side the tar particles are of relatively large dimensions, so large in fact that they can no longer be carried forward in the gas current and immediately separate out by gravity. All that is necessary for the complete separation of the tar from the gas is to provide a sump, or drip, into which the precipitated tar can drain.

6 It appears to be possible to secure almost any desired degree of gas cleanness simply by regulating the pressure maintained across the diaphragm. In ordinary commercial operation, it is found that a difference in pressure of from 2½ to 4 lb. will give a degree of gas cleanness that is ample for any commercial requirement. Thirty cubic feet of gas cleaned in this way can be passed through a white filter paper without producing any discoloration.

7 The distinction between this process and the process of purification by filtration can be best shown by outlining the conditions essential for each process:

- *a* In filtration the best separation is secured when the rate at which the materials to be separated pass the filtering medium is slow. One of the substances to be separated remains in the filter.
- *b* In the process in question good results can be secured only when the velocity of the gas passing through the diaphragm is very high. Nothing whatever remains in the diaphragm.

8 At low velocities the gas will pass through the porous diaphragm used in this apparatus without any apparent alteration, and the degree of effectiveness of cleaning is directly related to the velocity of flow. For example, the degree of cleanness produced with the velocity of flow resulting from 5 lb. pressure is very much greater than the degree of cleanness produced by the velocity of flow resulting from 1 lb. pressure, and when the velocities are as low as those produced by a pressure of a few ounces only, there is no perceptible change in the tar content of the gas after passing through the diaphragm.

9 No water is used in connection with this process except

that required to cool the gas. As a consequence there is no production of tar emulsion and the water flows from the condenser perfectly clear. The tar separated by this process is practically water free, and can accordingly be used for any purpose to which coal tar is adaptable. One sample of tar drawn directly from the receiver showed on distillation a water content of less than 1 per cent as compared with from 20 to 60 per cent which is ordinarily present in gas producer tar from mechanical washers. The calorific value of producer tar from Hocking coal is approximately 15,800 B.t.u. per lb., about 140,000 B.t.u. per gal.

10 For the maintenance of continuous operation the tar must be sufficiently fluid to pass through the porous diaphragm without creating undue resistance, and therefore it is necessary to maintain the temperature of the gas entering the diaphragm at a point that will reduce the viscosity of the tar to as low a point as is consistent with complete condensation of the tar vapors.

11 It is also apparent that this apparatus would not be well suited to use on gas containing large quantities of lamp black or for the purification of gas from coals yielding very heavy viscous tars. For high volatile coals, however, such as are found in Ohio, Indiana and Illinois, and for lignite, it has been found in practice to be thoroughly practical and effective. It is possible that further developments may extend the applicability of this method to conditions which are not now considered practical.

12 The exact method by which this tar extractor operates has not been conclusively demonstrated. Two theories have been advanced which may possibly cover the ground: The first and most obvious is that the tar particles are precipitated by being brought into direct collision with the threads or filaments of the porous diaphragm.

13 That this does not constitute a complete explanation of the process is indicated by the fact that the material of which the porous diaphragm is constructed has a marked bearing on the effectiveness of the process and would indicate some action other than simple mechanical collision. For example, if the porous diaphragm is made up of steel wool instead of glass wool (the physical structure of the diaphragm being as nearly as possible the same in each case) the process does not operate with anything like the effectiveness secured with glass diaphragms. It would seem that the possibility for collision would be the same in both cases.

14 A phenomenon, first observed by the writer in 1902 during some experimental investigations, gives further credence to the theory that there is some action other than pure mechanical collision. If the gas is caused to pass through a small tube with perfectly smooth walls, as for example a tube of glass, no particular precipitation of tar occurs as long as the velocities of travel are slow. However, as the velocities increase to a point where there is considerable friction between the gas and the surface of the containing tube a heavy precipitation of tar occurs on the surface of the glass. This fact leads to the conclusion that friction is in some way concerned in this process, since the probability of mechanical collision is rather remote. Since friction between rapidly moving gases and enclosing tubes is known to be productive of electrical phenomena, it was assumed that this might possibly have some bearing on the action of this process. In fact this interpretation was the one first placed upon the phenomenon observed in 1902 and an effort was made to work out a tar extractor along this line.

15 An experimental apparatus was constructed at that time in which heavily charged electrodes were employed to precipitate the tar particles and it was found that fairly effective results could be secured. Experiments along this line continued for a number of years, but the difficulties in the way of producing commercially practical apparatus caused its final abandonment. The rate at which the tar particles could be moved through the gas under the influence of moderate potential gradients was very slow. It was accordingly necessary to use exceedingly high potentials in order to secure effective results. With the spacing of electrodes of approximately 1½ in. a potential difference of 25,000 to 35,000 volts was required for effective precipitation. On account of the difficulty of maintaining proper insulation under these potentials and on account of the great danger of serious injury to an unskilled operator in manipulating apparatus of this kind, this method was not considered practical. It was noted, however, that by decreasing the distance between the electrodes a very marked decrease in potential was observed. Accordingly another experiment was devised which will perhaps throw still further light on the method of operation of the process under consideration.

16 A series of electrodes was prepared with exceedingly small intervening spaces, and placed in connection with a source

of direct electro motive force, the potential difference between the plates being much below that required to produce any ionizing discharge. It was found that at these small distances distinct cleaning effects could be obtained without ionization. Maintenance of the electric charge from external sources was troublesome owing to electrolytic short circuits occurring between the electrodes through deposits of tar and moisture from the gas. The fact, however, that there is a distinct attraction exerted by electrified plates at comparatively low potentials (which is sufficient to cause a precipitation of tar particles from gases) leads to the conclusion that if the distance between the electrodes could be reduced sufficiently the potential differences required for effective electrical action would be very small.

17 It would seem possible, therefore, that in addition to the effects of mechanical collision there might be a distinct electrical attraction exerted by the glass fibers constituting the porous diaphragm which are located at microscopic distances from each other and which are undoubtedly subjected to some electrification from friction with the gas currents. If the possibility of such electrical action is considered, the increased effectiveness of glass as compared with steel for the construction of the porous diaphragm is satisfactorily explained. That friction of this nature is capable of producing electrical disturbances of considerable magnitude is well established.

18 It might be interesting in this connection to refer to recent experimental determinations by Professor Dolezalek of Charlottenberg, Germany, who showed that the friction of liquid benzol against the sides of containing pipes may set up potential differences of as much as 3000 volts. As a very small fraction of this potential would be sufficient to account for the observed effects, it would seem only reasonable to presume that in addition to the effects of mechanical collision which undoubtedly exist, there is some electrical action which is of material aid in causing the coalescence of the particles of tar fog.

19 Whatever may be the correct explanation of the phenomenon, its effectiveness and practical importance are beyond question. The first commercial equipment of this kind has now been in continuous operation for approximately 18 months. This outfit is handling gas for a producer gas power plant of approximately 1000 h.p. capacity. The second commercial equipment is handling approximately 900 h.p. producer gas, and has

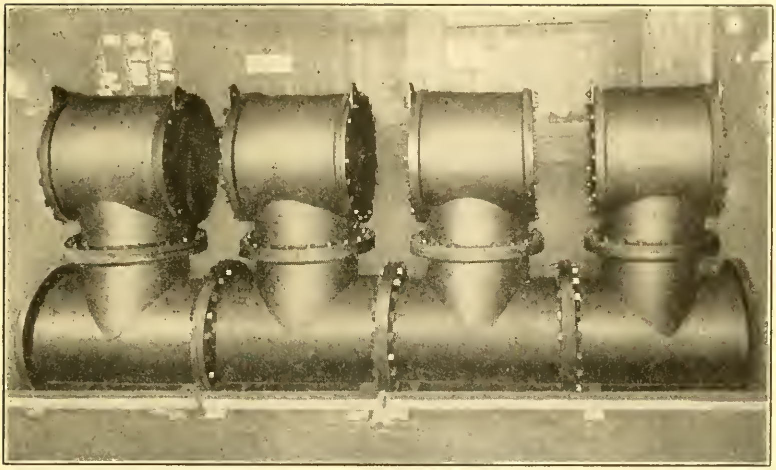


FIG. 2 SMITH TYPE F TAR EXTRACTOR. CAPACITY 250,000 CU. FT. PER HOUR

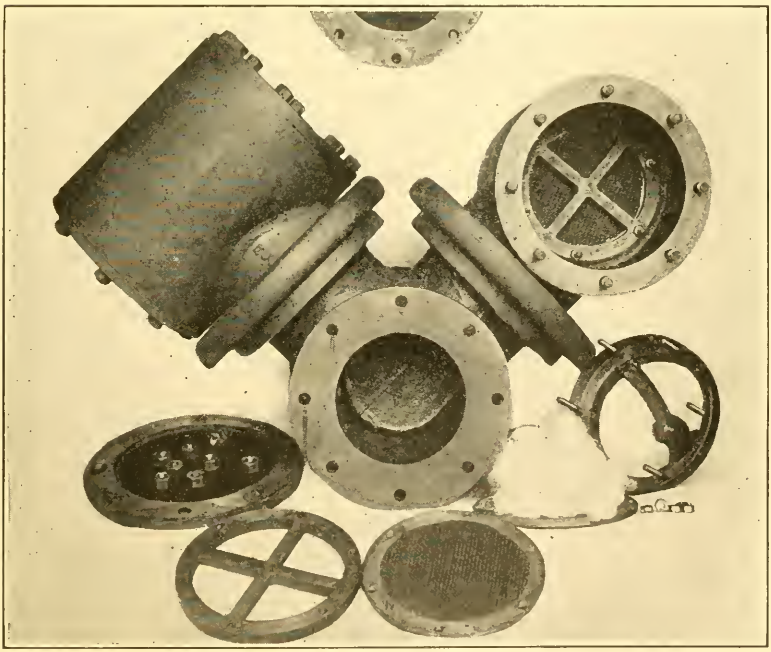


FIG. 3 VIEW SHOWING VARIOUS PARTS OF COMMERCIAL EXTRACTOR

been in daily service for approximately ten months. The largest single installation is an equipment for cleaning 200,000 cu. ft. of gas per hour. An idea of the dimensions and form of this equipment can be obtained from Figs. 2 and 3. This installation is operated in connection with a single producer unit which is of interest because it is one of the largest single unit plants ever installed in this country. This producer has an effective grate surface of 250 sq. ft. and is rated to gasify 3000 lb. of Illinois bituminous coal per hour.

EXTINGUISHING FIRES IN OILS AND VOLATILE LIQUIDS

By Edw. A. Barrier

ABSTRACT OF PAPER

The subject of the extinguishing of fires in such liquids as gasolene, lubricating oils, acetone, alcohol, ether, etc., is discussed; special reference is made to the new extinguishing agents for this class of materials: carbon tetrachloride, sawdust and bicarbonate of soda, and frothy mixtures. The properties of these extinguishing agents, the conditions under which they are the most efficient, and their limitations, are considered.

EXTINGUISHING OF FIRES IN OILS AND VOLATILE LIQUIDS

Edw. A. Barrier,[1] Boston, Mass.

Non-Member

The extinguishing of fires in oils and in most of the volatile liquids has always been a difficult problem and where fires of this kind occur the results are frequently very disastrous. Our most common extinguishing agent, water, works rather unsatisfactorily upon the majority of such fires, but it is still the only one available where heroic measures are required. Comparatively recently, however, there have been two or three other materials introduced for use as extinguishers which have shown some promise for dealing with these fires, and it is the purpose of this paper to discuss these materials and the conditions under which they prove the most efficient.

2 Not all fires in volatile liquids are difficult to handle with water. When the liquid is miscible with water this extinguishing agent can be successfully used. Examples of this kind are denatured alcohol, wood alcohol, grain alcohol, acetone, etc. Where the liquid is not miscible with water little or no effect is produced except to wash the burning liquid out of the building where it may be completely consumed or, if the quantity of oil is small, possibly to extinguish the fire by the brute cooling effect of a large quantity of water sprayed upon the fire. Soda and acid extinguishers are somewhat more effective than pure water, but even they fail under most conditions. The various grenades containing salt solutions which were formerly extensively exploited are of course practically worthless.

3 The only principles that can be made use of in extinguishing fires in volatile oils are, (*a*) to form a blanket either of gas

[1] Inspection Department, Associated Factory Mutual Fire Insurance Companies, 31 Milk Street.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

or of solid material over the burning liquid which will exclude the oxygen of the air, or, (*b*) to dilute the burning liquid with a non-inflammable extinguishing agent which is miscible with it.

SAWDUST AND BICARBONATE OF SODA

4 To the blanketing type of extinguishers belongs sawdust. Paradoxical as it may seem, ordinary sawdust is an excellent extinguishing agent for certain volatile liquids, especially those of a viscous nature. A considerable number of experiments were conducted in the fall of 1912 by the inspection department of the Associated Factory Mutual Fire Insurance Companies, in the extinguishing of fires in lacquer and gasolene in tanks with sawdust, and the results were surprisingly satisfactory.

5 The liquids were placed in three tanks 30 in. long, 12 in. wide and 16 in. deep; 48 in. long, 14 in. wide and 16 in. deep; and 60 in. long, 30 in. wide and 16 in. deep. The sawdust was applied with a long-handled, light but substantially built snow shovel having a blade of considerable area. In every case the fires were extinguished readily, especially in the two smaller tanks which were about as large as any ordinarily employed for lacquer in manufacturing establishments.

6 The efficiency of the sawdust is undoubtedly due to its blanketing action in floating for a time upon the surface of the liquid and excluding the oxygen of the air. Its efficiency is greater on viscous liquids than on thin liquids, since it floats more readily on the former than on the latter. The sawdust itself is not easily ignited and when it does become ignited it burns without flame. The burning embers have not a sufficiently high temperature to reignite the liquid.

7 The character of the sawdust, whether from soft wood or hard wood, appears to be of little or no importance, and the amount of moisture contained in it is apparently not a factor, so that the drying out of sawdust when kept in manufacturing establishments for a time would not effect the efficiency.

8 It was found that the admixture of sodium bicarbonate greatly increased the efficiency of the sawdust as shown both by the shortened time and the decreased amount of material necessary to extinguish the fires. A further advantage of the addition of bicarbonate of soda is that it decreases the possible danger resulting from the presence of sawdust in manufacturing plants since it would be difficult, if not impossible, to ignite

the mixture by a carelessly thrown match or any other ready source of ignition.

9 Although the efficiency of the sawdust is greatest on viscous liquids such as lacquers, heavy oils, Japan, waxes, etc., in the tests referred to, fires were extinguished in gasolene contained in the smallest tank and also when spread upon the ground. In larger tanks the sawdust or bicarbonate mixture does not work so well since the sawdust sinks before the whole surface can be covered, whereupon the exposed liquid reignites.

CARBON TETRACHLORIDE

10 In recent years carbon tetrachloride has received considerable attention as a fire-extinguishing agent. This is due largely to the activity of certain manufacturers of fire extinguishers which use liquids, the basis of which is carbon tetrachloride.

11 This substance is a water white liquid and possesses when pure a rather agreeable odor somewhat similar to chloroform. A considerable proportion of the commercial article upon the market, however, contains sulphur impurities which impart a disagreeable odor to the liquid. The substance is quite heavy, its specific gravity being 1.632 at 32 deg. fahr. It is non-inflammable, non-explosive, and is readily miscible with oils, waxes, japan, etc. When mixed with inflammable liquids it renders them non-inflammable provided a sufficient quantity is added. Its vapor is heavy, the specific gravity being about five and one-half times that of air, consequently it settles very rapidly. As an extinguishing agent it operates by both the principles mentioned in Par. 3, namely, it dilutes the inflammable liquid rendering it non-inflammable, or at least less inflammable, and it forms a blanket of gas or vapor over the burning liquid which excludes the oxygen of the air.

12 Although this paper is confined to a discussion of extinguishing fires in oils and volatile liquids, it may not be out of place to mention that the claims made by certain manufacturers producing extinguishers which use liquids, the basis of which is carbon tetrachloride, are grossly exaggerated. These preparations, none of which is more efficient than carbon tetrachloride, are not the equivalent of the ordinary water extinguishers for general use on such materials as cotton, wood, paper, oily waste, etc.

13 On volatile liquids, oils, etc., carbon tetrachloride has, however, shown very satisfactory results under some conditions, but the readiness with which a fire can be extinguished with it depends to a considerable extent upon the skill of the operator and the nature of the fire. In tank fires the length of time that the liquid has been burning is an important factor, and in such cases where the sides of the tank become heated the only way in which the fire can be extinguished is to squirt the liquid forcibly at the sides. If the carbon tetrachloride is squirted directly into the liquid it is much more difficult, if not impossible, to extinguish the fire.

14 The height of the liquid in the tank is also a very important factor. Where the liquid is low the sides form a pocket which retains the vapor and aids considerably in smothering the blaze. When the tank is nearly full, however, this condition does not exist, and it is then very difficult, if not impossible, to extinguish a fire in a highly volatile liquid, such as gasolene; only the most skilled operators are successful in these cases. The size of the tank or the extent of the fire if upon the floor is, as would be expected, of considerable importance. In tanks larger than about 28 in. by 12 in. more than one extinguisher and operator working at a time are necessary to extinguish a fire in such materials as gasolene. In one test where a tank 60 in. by 30 in. was used no less than seven operators were necessary, and even then it was only with the greatest difficulty that the fire was put out.

15 All of the above remarks apply to carbon tetrachloride in the ordinary one-quart extinguisher as generally sold. It is probable that a large extinguisher which could throw a large stream would prove more efficient, but on account of the great weight of carbon tetrachloride such an extinguisher would have to be specially designed to make it readily portable by mounting on a truck or some similar means. Expelling the liquid by means of a hand-pumping arrangement would probably be unsatisfactory, and it would therefore be necessary to force it out in some other way.

16 A few systems have recently been installed in which an elevated tank containing carbon tetrachloride was connected with automatic sprinklers or perforated pipes located in hazardous rooms where volatile and inflammable liquids are in use. So far as is known none of these systems have as yet been called

upon to extinguish a fire, but there appears to be no reason why such a system should not provide excellent protection in special cases. In such systems it would be necessary to consider the safety of the workmen and furnish ready means of escape, since carbon tetrachloride is an anesthetic and where thoroughly sprayed through the air as from an automatic sprinkler it would probably produce rapid results.

17 The nature and effect of the fumes given off when carbon tetrachloride is thrown upon a fire is a subject which has received a great deal of discussion. When the liquid comes in contact with a fire the vapor is partly decomposed resulting in the evolution of a considerable quantity of black smoke which is undoubtedly finely divided carbon. Pungent gases are also produced which appear to be mostly hydrochloric acid with possibly a small amount of chlorine. Since carbon tetrachloride contains no hydrogen from which hydrochloric acid could be formed this substance must be produced by the action of chlorine on the gases arising from the burning material or upon the moisture of the air.

18 The fumes of carbon tetrachloride although of a very pungent nature do not produce any permanent injury under ordinary conditions where the operator can make his escape after he has inhaled all that he can stand, but they are a distinct handicap in fighting a fire and are one of the objectionable features to carbon tetrachloride as a general fire extinguishing agent. In large rooms or where a small quatity of carbon tetrachloride is sufficient to extinguish a fire the gases are of course less objectionable.

FROTHY MIXTURES

19 Another method of extinguishing fires in oils and volatile liquids which has recently been proposed and experimented with is that of using frothy mixtures. The idea seems like a very promising one and the tests which have been thus far reported indicate very satisfactory results. The idea was originated and has been developed in Germany. So far as is known no experiments have been conducted in this country.

20 The process consists essentially in causing two liquids to mix in a tank where foam is produced. The tank is made airtight and sufficiently strong to permit of the foam being forced out by carbon dioxide under pressure, and the foam is conveyed

to the fire by means of a line of hose. The exact nature of the liquids has not been disclosed, but one of them probably consists of a sodium carbonate solution containing froth-forming ingredients such as glue or casein and the other an alum solution. The two on coming together generate carbon dioxide which produces froth. This froth is reported to be quite stiff and to shrink in volume but a comparatively small amount even after a period of half an hour.

21 A number of tests were conducted in the winter of 1912 in Germany; some of them on a considerable scale. In one case as much as 5 tons of crude naphtha in a tank was involved, and in another an area of 1300 sq. ft. of burning tar was used. In all cases the results were reported satisfactory, the fires being extinguished in a short time.

22 The frothy mixture undoubtedly owes its efficiency to its blanketing action in settling upon the surface of the burning liquid, thus excluding the oxygen of the air, and to the fact that the bubbles of liquid contain carbon dioxide which upon bursting produce an atmosphere in which combustion cannot take place.

23 According to the latest reports the matter is still in an experimental stage, various details regarding the form of apparatus, most efficient pressure, and design of nozzles being under consideration; but from what has already been done it would appear that the idea is a very promising one, and that this method of extinguishing fires in oils and volatile liquids will prove to be by far the most efficient of any that has as yet been suggested.

THE PROPERTIES OF STEAM

By R. C. H. Heck

ABSTRACT OF PAPER

This paper offers a new pair of characteristic equations for steam, which give specific volume and heat content (total heat) respectively in terms of pressure and temperature as independent variables. These equations must be and are connected by certain mathematical relations from thermodynamic theory; and at saturation they are in very close agreement through Clapeyron's equation.

Especial emphasis is laid upon the shape of isothermal curves in plots of the pressure-volume product and of heat content on pressure as base. Heretofore, the data for such curves have been volumetric only. Now a new determinant is introduced, in an application of throttling data which gives a very good layout of the total-heat isothermals.

The several lines of experimental determination have been volume measurement, total heat of saturated steam, specific heat of superheated steam, and rate of change of temperature with pressure in throttling (during which total heat remains constant). Bringing the last fully into the problem doubles the field of experimental influence upon the form of the characteristic equations, and greatly extends the range of conditions over which at least some data are now available.

An important feature of the paper, little more than suggested in the following abstract, is the group of graphical comparisons with the physical data and with other formulations: these others are, the tables or formulas of Marks and Davis, of Mollier (Callendar), of Linde, and of Goodenough. The last are used as published by the Society in Volume 34, Page 507 of Transactions.

Because the equations here presented are a little more than usually complicated in the form of the terms which show the departure of steam from an ideal "perfect" gas, numerical values of the several factors have been worked out for every 10 deg. up to 1000 deg. fahr. and at suitable pressure intervals up to 1000 lb. per sq. in. Beside this table for superheated steam (in the complete paper) there is also a table for saturated steam with temperature as argument and the same range and spacing.

THE PROPERTIES OF STEAM[1]

By R. C. H. Heck, New Brunswick, N. J.

Member of the Society

The fundamental physical properties of steam are pressure p, temperature t, specific volume v, and heat content or total heat h. Of these, p and t are taken as independent variables, and equations expressing v and h in terms of them are developed. From these the values of internal energy, entropy, specific heat, etc., can be calculated.

2 Two relations from thermodynamic theory find useful application in connecting volume and heat formulae, namely

$$\left(\frac{dc_p}{dp}\right)_t = -AT\left(\frac{d^2v}{dt^2}\right)_p \qquad [1]$$

and

$$\left(\frac{dh}{dp}\right)_t = -A\left[T\left(\frac{dv}{dt}\right)_p - v\right] \qquad [2]$$

And at saturation, where p and t cease to be independent of each other, there must be satisfaction of Clapeyron's equation

$$\frac{r}{u} = AT\frac{dp}{dt} \qquad [3]$$

where r is latent heat and u is the increase of volume from water to steam during vaporization.

3 The two general equations developed in the paper are as follows:

a Volume Equation

$$pv = BT - yp - zp^{2.4} \qquad [4]$$

B is the gas constant for H_2O, determined by molecular weight and taken as 0.5956, for units as defined in Par. 4.

[1] This paper is published in abstract only. The complete form is on file and may be referred to in the rooms of the Society.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

$$y = \frac{[4.66365]}{(t+130)^2} \quad\ldots\ldots\ldots\ldots\ldots\ldots [5a]$$

$$z = \frac{[11.02244]}{(t+40)^6} \quad\ldots\ldots\ldots\ldots\ldots\ldots [5b]$$

b Heat Equation

$$h = h_\circ - y'p - z'p^{2.4} \quad\ldots\ldots\ldots\ldots\ldots\ldots [6]$$

$$y' = \frac{[4.40815]}{(t+130)^2} + \frac{[6.75057]}{(t+130)^3} \quad\ldots\ldots\ldots\ldots [6a]$$

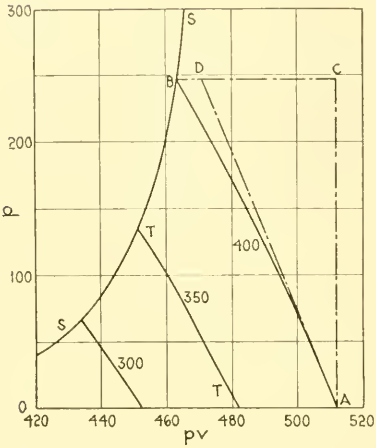


Fig. 1 Isothermals of pv on p

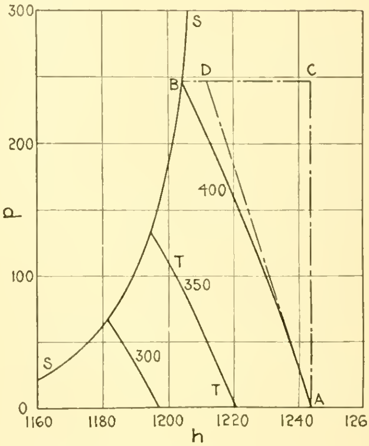


Fig. 2 Isothermals of h on p

$$z' = \frac{[10.75471]}{(t+40)^6} + \frac{[13.31101]}{(t+40)^7} \quad\ldots\ldots\ldots\ldots [6b]$$

$h_\circ$ is the total heat at zero pressure given by the formula

$$h_\circ = 309.64 + 0.3020\, t + [2.42163] \log(t+688) + 0.000072\, t^2 \ldots [7]$$

4 These equations are for English units, with p in pounds per square inch absolute, t or $T = (t+459.64)$ in degrees fahrenheit, v in cubic feet per pound of steam, and heat quantities in the mean British thermal unit. In the paper all formulae are also converted to metric-centigrade units. One special notation adopted is the giving of the logarithm of a constant, thus [4.66365] in equation [5a], in place of the number itself.

5 Equations [5] and [6] are illustrated directly by Figs. 1 to 4, their derivatives by Figs. 5 and 6. Instead of the volume v, which varies so widely with pressure, the product pv is plotted in every case. These three pairs of companion diagrams show the close

analogies in behavior between external energy pv and heat content h. In Figs. 1 to 6 curve SS is the saturation line, the lower limit of the field covered by the general equations.

6 In Figs. 1 and 2, strong emphasis is laid on the isothermal

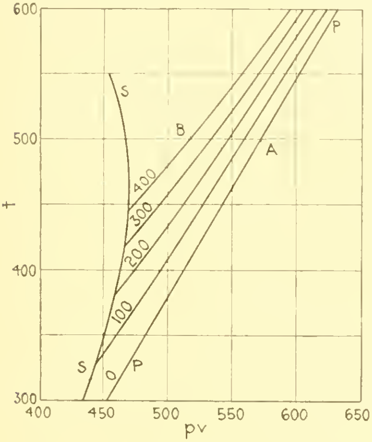


FIG. 3 EXPANSION AT CONSTANT PRESSURE

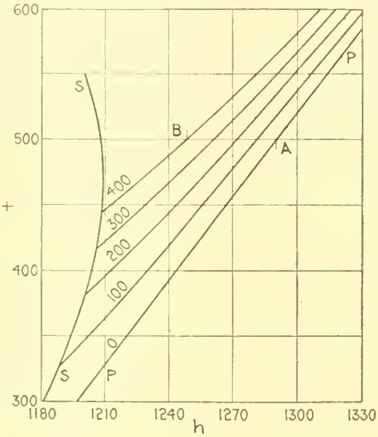


FIG. 4 HEATING AT CONSTANT PRESSURE

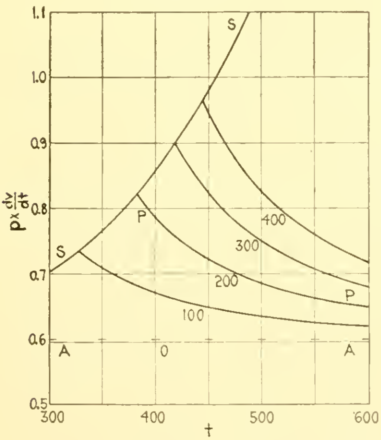


FIG. 5 RATES OF EXPANSION

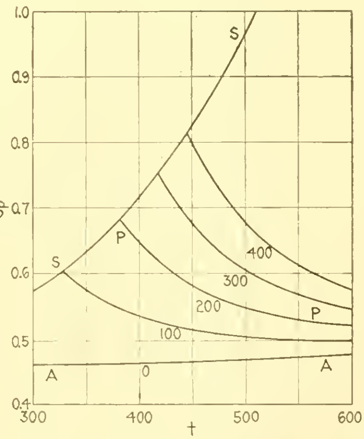


FIG. 6 CURVES OF SPECIFIC HEAT

curves TT. For a perfect gas, pv or h would be constant with temperature, or either isothermal would be a vertical line like AC. Actually, and especially toward saturation, there is a shrinkage: the straight line AD shows the effect of term yp or $y'p$, while $zp^{2.4}$ or $z'p^{2.4}$ adds curvature to the isothermal.

7 Change under constant pressure is shown in Figs. 3 and 4,

where each curve of type PP is marked with the value of its uniform pressure in pounds absolute. In Fig. 3, the line for zero pressure represents the straight-line variation of ideal pv (or BT) with temperature; and any distance like AB shows the shrinkage from ideal to actual, along the isothermal and with rise of pressure. In Fig. 4, the line for zero pressure is not straight because the specific heat is not constant but rises slowly with the temperature.

8 Figs. 5 and 6 show rates of change under constant pressure, still retaining the factor p with v. The derivatives from equations [5] and [6] are, for Fig. 5

$$p\left(\frac{dv}{dt}\right)_p = B - p\frac{dv}{dt} - p^{2\cdot 4}\,\frac{dz}{dt} \qquad \text{[8]}$$

for Fig. 6

$$c_p = c_{po} - p\frac{dy'}{dt} - p^{2\cdot 4}\,\frac{dz'}{dt} \qquad \text{[9]}$$

The y and z derivatives are negative so that the secondary terms add themselves to the first, principal term, and the curves are higher as the pressure is greater.

USE OF THROTTLING DATA AND RELATIONS

9 Heretofore, all determination of the shape of the isothermals in Figs. 1 and 2 has been by volume data. The paper introduces a new determinant on the side of heat content, based upon throttling data. The operation of throttling is one in which the pressure and temperature fall while the heat content remains unchanged. In Fig. 7 the three important groups of throttling experiments on record are plotted together, in comparison with curves of uniform total heat from equation [6]. Here, on p as base and with t as ordinate, are h-constant curves and t-constant horizontal lines. In Fig. 2, taking vertical p as base and h as ordinate, there are t-constant curves and h-constant vertical lines. Evidently, the slope of the throttling curves in Fig. 7 must have a direct bearing upon the slope of the isothermal curves in Fig. 2.

10 The relation is established as follows: from the general statement $h = f\,(p, t)$, write the differential equation

$$dh = \left(\frac{dh}{dp}\right)_t dp + \left(\frac{dh}{dt}\right)_p dt \qquad \text{[10]}$$

Now impose the condition $h = \text{constant}$ or $dh = 0$, and get for the rate of change of h with p when t is constant, or the slope from the vertical of the isothermal in Fig. 2, the value

$$\left(\frac{dh}{dp}\right)_t = -\left(\frac{dh}{dt}\right)_p \left(\frac{dt}{dp}\right)_h = -c_p\mu \ldots\ldots\ldots\ldots\ldots [11]$$

The specific heat c_p under constant pressure is, of course, the rate of change of heat with pressure for p constant, or $\left(\frac{dh}{dt}\right)_p$; and μ or

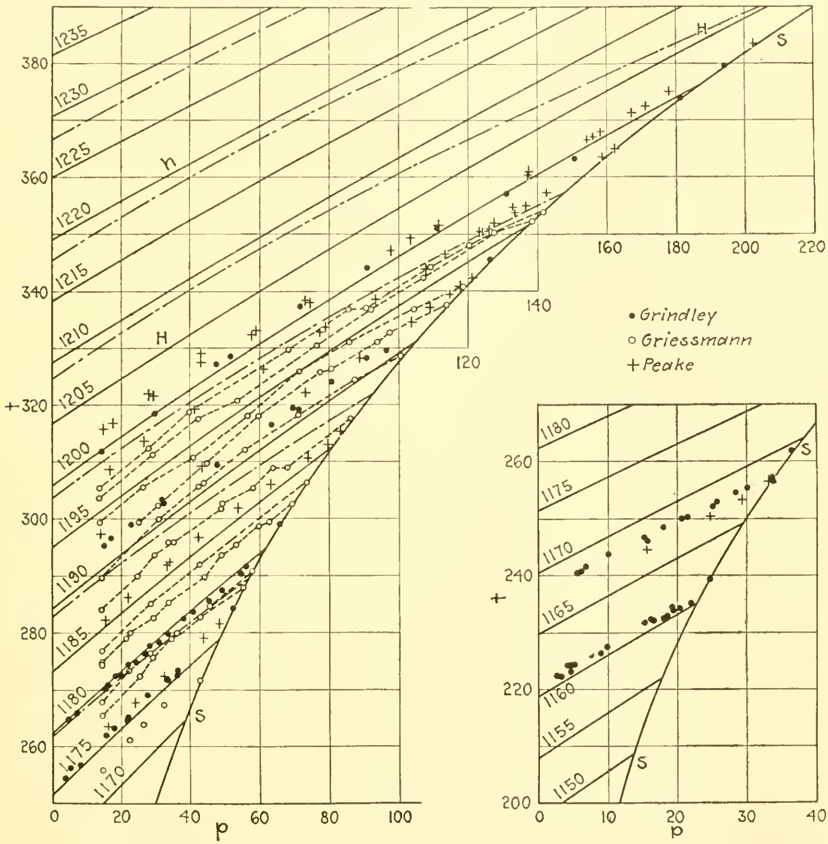


FIG. 7 THROTTLING EXPERIMENTS WITH STEAM INITIALLY SATURATED

$\left(\frac{dt}{dp}\right)_h$ is the throttling coefficient, the slope of the constant-heat curves in Fig. 7.

11 There is considerable experimental information concerning other gases as well as steam, which seems to indicate that μ is nearly or quite independent of p and h, being a function of t alone. If this

is true, any horizontal line of constant temperature in Fig. 7 will be crossed at the same angle by all the throttling curves which it intersects. And if these separate curves have all the same slant at any particular temperature, they may by horizontal shifting be brought into coincidence as one continuous curve.

12 The first step in an investigation along the line of these principles is to assume, for the time being, that μ is constant with t. A curve of μ on t has been laid out by H. N. Davis for the range from 250 deg. to 625 deg. fahr. With this as a start, to be modified by the reaction of trial calculations, a smooth curve of μ on t has been developed up to 1000 deg. and back to 32 deg. By numerical integration of $\frac{1}{\mu}$ or $\left(\frac{dp}{dt}\right)_b$, the general throttling curve is obtained with base t and an arbitrary pressure ordinate p'; that is, the scale of this p', in pounds per square inch, will be used for measuring differences of pressure, not absolute values.

13 Next it is necessary to get the specific heat c_{po} at zero pressure and from it the corresponding total heat h_o. The Knoblauch experiments are taken as authoritative, especially the later set. It is shown that a vertical h-constant line in a plot like Fig. 2 is cut at the same angle by all the isothermals crossing it, or that with p and h as coördinates the product $c_p\mu$ from equation [11] is constant along a line of uniform heat content. By means of this relation, it is easy to reduce the specific heat observations to zero pressure. Over high ranges of temperature, say from 500 to 1100 deg. fahr., the curve of c_{po} is thus very definitely determined. Toward the lower limit of the experiments (at about 300 deg.) there is poorer consistency, indicating probably that the validity of the method of reduction is weakened by approach to saturation. But there are other data in Fig. 7 and in the close experimental determination of total heat of saturated steam at low temperatures, which fix very definitely the mean value of c_{po} from 212 deg. to 32 deg. fahr. The curve as finally adopted has the equation

$$c_{po}=0.3020+\frac{[2.05941]}{t+688}+0.000144\,t \ldots\ldots\ldots\ldots [12]$$

And with the proper constant of integration this leads to equation [7].

14 The method of determining the isothermal of heat content on pressure by means of the general throttling of constant-heat curve is illustrated in Figs. 8 and 9. Curve HH is a short portion of the constant-heat curve, p' on t. The particular problem taken is that of finding dimensions of the h-p isothermal for 500 deg. fahr., up to

300 lb. absolute pressure. In Fig. 8, this isothermal is the vertical line AB. From A measure down, to the scale of p', a series of 50 lb. intervals, and draw horizontal intercepts like CD. Then CD is the temperature gap (after a drop of 200 lb.) between a t-constant line AC and an h-constant line AD which have a common point at A. Now transfer these CD differences to Fig. 9, using the scale of temperature corresponding to successive values of h_0 which is laid off above the base line. The result is a series of points along the isothermal TT.

15 This scheme is complete in itself, but the data are by no

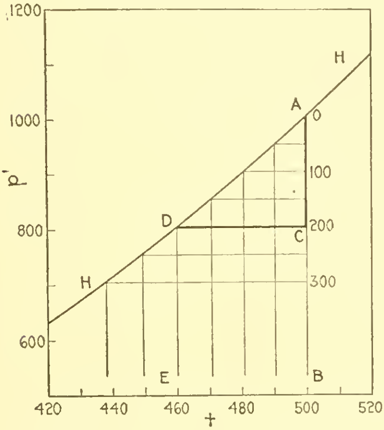


Fig. 8 Use of the Throttling Curve

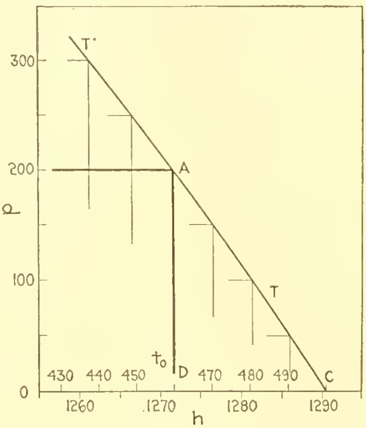


Fig. 9 Determination of h-p Isothermal

means accurate enough to make it a complete determinant; nor can the hypothesis that μ depends upon t alone be accepted as rigorously correct. The method followed has been to obtain by this device a set of isothermals as in Fig. 2, and from them find approximate values of the functions y' and z' and the exponent of p in the last term of equation [6]. Then the task has been to cut and try and adjust constants until equations [5] and [6], tied together by relations [1] and [2], will satisfy, as nearly as possible, Clapeyron's equation at saturation.

16 One point remains to be considered before discussing the general equations. It is reasonable to assume that the simple law apparently making μ almost, if not wholly, a dependent upon t alone will have least modification by secondary influences when the pressure is low. From equations [6] and [11] for $p=0$ is obtained the particular relation

$$\left(\frac{dh}{dp}\right)_t = -y' = c_{po}\mu_o \ldots\ldots\ldots\ldots\ldots\ldots [13]$$

and the curve and tabular column of μ, as given in the paper, is really this μ_o, found after the form of y' had been determined partly by other considerations, through division of y' by c_{po}.

DISCUSSION AND COMPARISONS

17 Concerning the process of developing equations [5] and [6], there is nothing to be added to the brief description in Par. 15. All the data in the several departments of physical experiment were used as checks while the adjustments were being made; and after the formulae were fixed in form and constants, final diagrams were laid out to show, by graphical comparison, the relation of this formulation to the data and to certain other formulations.

18 The comparisons with throttling and specific-heat data are as follows:

a the curve of μ on t, with Davis' curve and points showing his collection of the data into group means, from his paper on The Law of Corresponding States

b the classic throttling experiments made with steam initially superheated, here given as Fig. 7

c the experiments of Dodge upon highly superheated steam. This makes for completeness, but serves chiefly to show lack of determinative value, as the experiments show how extremely difficult it is or will be to get reliable values of μ at high temperatures and pressures

d the Knoblauch-Jakob and Knoblauch-Mollier experiments on specific heat, and the curve of c_{po}

e The experiments of Thomas, which show large inconsistencies.

In every case, only the formulation of the paper enters into these comparisons; except that a few lines (dot-and-dash)in Fig. 7 are from Mollier's heat equation.

19 To illustrate the degree of consistency of results by different methods within the investigation, several diagrams are given:

a Specific heat c_{ps} at saturation, from equation [9] by proper evaluation and also from Planck's equation

$$c_{ps} = \frac{dh_s}{dt} - \frac{r}{T} + \frac{r}{u}\left(\frac{dv}{dt}\right)_p \ldots\ldots\ldots\ldots\ldots\ldots [14$$

The agreement is exceedingly close.

b Isothermals from equation [6] in comparison with those

obtained by the method of Figs. 8 and 9. There is enough discrepancy to illustrate the fact, as does Fig. 7 also, that complete constancy of μ with t is not secured in the final formulation.

20 On the side of volume data, the experiments of Knoblauch, Linde, and Klebe, of Ramsay and Young, and of Battelli are plotted on diagrams of the type of Fig. 1, in comparison with isothermals from equation [5]. The first set are the only ones now having determinative value, but they are of the first importance.

21 The real determinant in the close adjustment of equations [5] and [6] to each other was the satisfaction of Clapeyron's relation. In this connection it was found desirable to make a slight adjust-

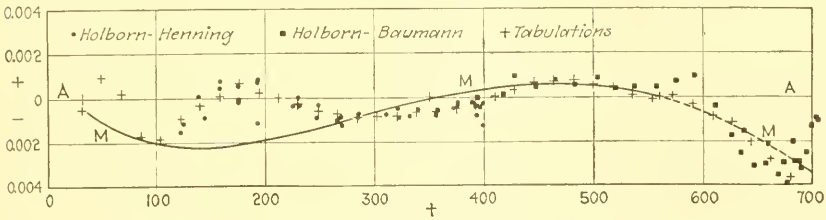


FIG. 10 PRESSURE-TEMPERATURE COMPARISONS

ment of Marks' equation for the pressure-temperature relation of saturated steam. This formula is

$$\log p = A - \frac{B}{T} - CT + DT^2 \dots\dots\dots\dots\dots [15]$$

and the two sets of constants are

	(a) Marks	(b) Heck
$A =$	10.515345	10.606400
$\log B =$	3.6878597	3.6897500
$\log C =$	7.6075880 − 10	7.6205462 − 10
$\log D =$	4.1439400 − 10	4.1601803 − 10

The absolute temperature is taken as $T = t + 459.64$.

22 These equations are compared in Fig. 10, where straight line AA represents equation [15b] and the ordinate is fraction of departure from p as given by this formula. Curve MM is the original Marks equation, and the plotted points show the data. A principal reason for making the change is that [15a] makes $p = 14.672$ lb. at 212 deg. instead of the proper value 14.697.

23 Various evaluations and tabulations of total heat h_s at saturation are compared in Fig. 11. The base lines AA represent equation [6]; but here the ordinate is the actual difference in B.t.u., not the relative difference as in Fig. 10. The curves on the upper AA line

are concerned with the matter of adjusting equations [5] and [6]. Curve 1 shows h_s as derived from h_0 by the method of Figs. 8 and 9. Curve 2 is the real criterion of consistency between the principal equations, for it represents the total heat derived from volume data, or from equation [5]. Up to 500 deg. or about 600 lb. pressure, the

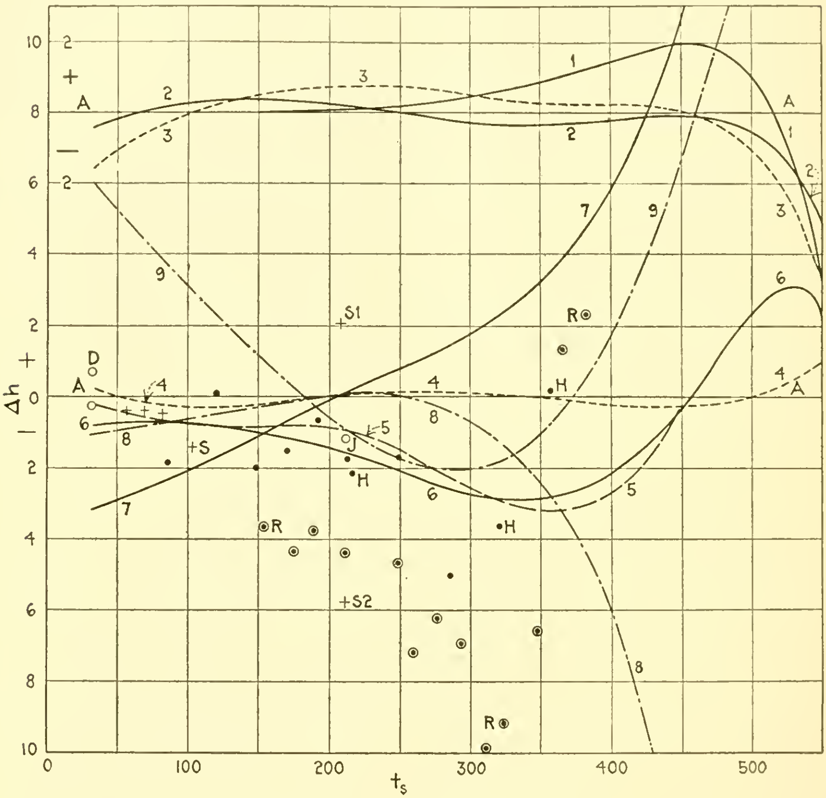


Fig. 11 Comparisons of Total Heat at Saturation

discrepancy is everywhere less than 0.5 B.t.u., or barely exceeds 0.03 per cent. Curve 3 shows results of the same calculation, but made with values of p and r/u from the original Marks equation.

24 The curves referred to the lower AA line in Fig. 11 are of wider scope. First, Curve 4 shows how very nearly h_s from equation [6] is represented by the third-degree equation

$$h_s = 1059.75 + 0.4344\,t + 0.0001829\,t^2 - 0.0000009215\,t^3 \ldots\ldots [16]$$

The curves with numbers higher than 4 represent other formulations, as follows:

No. 5 Marks and Davis *Steam Tables*

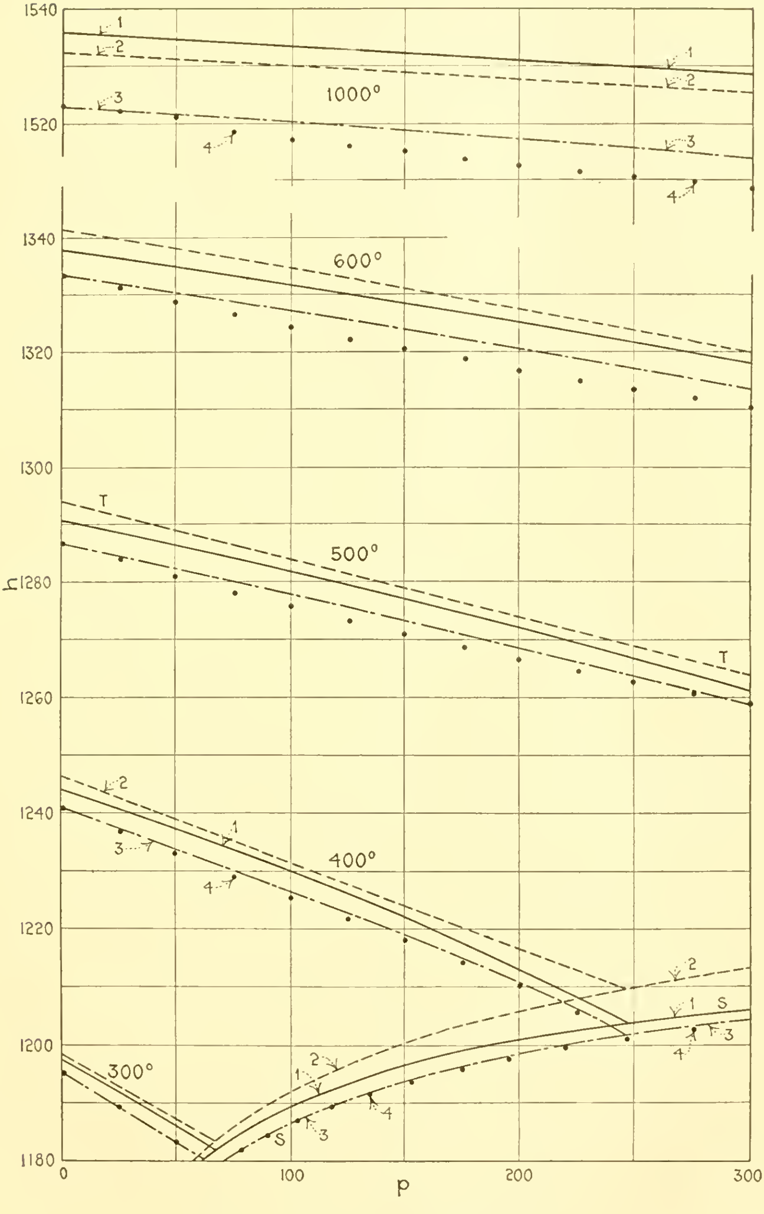


Fig. 12 Total Heat Comparisons

No. 6 the writer's table in *The Steam Engine and Turbine*
No. 7 Mollier's *Neue Tabellen und Diagramme für Wasserdampf,* also Smith and Warren's *New Steam Tables*
No. 8 a heat equation from the work of Linde
No. 9 Goodenough's equation, published in Transactions of the Society, Volume 34.

25 With these curves are given the experimental results obtained by various investigators: the initials used are, *D* for Dieterici, *H* for Henning, *J* for Joly, *R* for Regnault, *S* for Smith. The Regnault points represent group averages made up by Smith. The points marked *S*1 and *S*2 are of especial interest, as representing A. W. Smith's recent determinations with slow and with rapid vaporization under atmospheric pressure, reported in Physical Review, September 1911. The determining value of h_s at 212 deg. is 1151.2 B.t.u. by equations [6] and [7] as against 1150.4 by Marks and Davis and 1151.4 used by Mollier.

26 In Fig. 12 a comparison over the practical range of steam pressure and temperature is made between the heat equations of this paper and those of the other formulation which have been put into the form of complete steam tables. Full lines 1 represent equation [6], dotted lines 2 the Mollier equation; curves 3 are from the writer's[1], earlier work points 4 from the Marks and Davis tables for superheated steam. Mollier's saturation curve runs high (compare Fig. 11), and his isothermals are straight lines instead of curves. The Marks and Davis total heats depend upon a wholly empirical and graphical extrapolation of c_p above the comparatively low pressures of the Knoblauch experiments; and the reversed curvature of the isothermals shows that their c_p is relatively too great at high pressures and near to saturation. In the writer's earlier work, a graphical layout and extrapolation of c_p was guided by heat isothermals obtained through the method of the general throttling curve. Dependence upon the Holborn-Henning determination of high range c_p for atmospheric pressure is the reason why isothermals 3 and 4 at 1000 deg. are about 15 B.t.u. below No. 1.

27 Fuller discussion and comparison of the different formulations are given in the paper. To it is appended tables giving at intervals of 10 deg. up to 1000 deg. all the numbers for making calculations by equations [5] and [6] and their derivatives, with pressure factors up to 1000 lb.; also a table for saturated steam at similar intervals up to 550 deg. or past 1000 lb.

[1] Steam Engine and Turbine.

CAST IRON FOR MACHINE-TOOL PARTS

By Henry M. Wood

ABSTRACT OF PAPER

As this paper treats the subject of cast iron from the viewpoint of the machine-tool manufacturer and user, foundry technicalities have been avoided. A brief outline of the influence of different elements on ordinary cast iron is presented so that manufacturers who are not closely in touch with foundry practice may better understand the analyses quoted later.

Letters from several representative machine-tool manufacturers are quoted, giving their practices in the use of various mixtures, with chemical analyses of irons used for special purposes.

Reports are also presented from a number of manufacturers on the use of chilled castings, which show a considerable difference of opinion, but indicate in general that the use of chills for certain surfaces of machine tools is on the increase.

CAST IRON FOR MACHINE-TOOL PARTS

By Henry M. Wood, Cincinnati, Ohio

Associate Member of the Society

When considering what sort of iron to use for various purposes, the machine-tool manufacturer is interested chiefly in the result attained by the foundryman, i. e., the strength, soundness, hardness, etc., of the casting, rather than the foundry methods used in accomplishing such result. Nevertheless as an investigation of the character of the casting is made through chemical analysis, it is well first to consider the effect of each of the elements usually present in cast iron.

INFLUENCE OF CHEMICAL ELEMENTS

2 The five elements present in ordinary cast iron are carbon (both free as graphite and combined), silicon, sulphur, manganese, and phosphorus.

3 *Carbon.* Carbon exerts a more important and direct influence on the quality of the metal than does any other element. The percentage of carbon in the casting and the form in which it exists are dependent upon the melting conditions, the thermal treatment, and the amounts of other elements present. It is therefore necessary to take account of the effects of the carbon itself and the way its influence is modified by the presence of varying quantities of other elements. To obtain a proper relation between combined and free carbon is the most important point. The percentage of total carbon usually ranges from 3.5 to 4.

4 *Graphitic Carbon.* Graphite is merely mixed with the iron instead of being in chemical combination. Since it is only mixed with the metal it cannot exert any direct influence upon the properties of the molecules of the iron. So far as the graphite itself is concerned the toughness, hardness, and melting point of the grains of

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

the iron will not be altered. The tensile strength will, however, be greatly affected, since the interposition of the flakes of graphite will act as partings between the grains of the metal and reduce the cohesion. Iron high in graphite is soft and can be readily machined, but is of low tensile strength.

5 *Combined Carbon.* The carbon which is in chemical combination affects directly and greatly the properties of ordinary cast iron. It is the principal factor in determining the hardness, tenacity, soundness, and freedom from internal stresses of the castings. In general the percentage of combined carbon ranges from 0.05 in the softest cast iron to about 0.60 in iron of the highest elasticity. With suitable iron mixtures the amount of silicon and sulphur present regulates separation of carbon as graphite so that the amount of silicon present is an index of the relation between the free and combined carbon. Many analyses submitted do not state the percentage of carbon, perhaps because the foundrymen do not appreciate the importance of it, or perhaps because they consider the quantities of silicon, manganese and sulphur, which influence the quantity of combined carbon, make it unnecessary to determine the latter.

6 *Silicon.* Silicon tends to cause separation of the carbon as graphite. As the hardening effect of the silicon necessary to do this is less than that of the combined carbon converted into free carbon the net result of adding silicon is softer iron. Under conditions which are easily regulated by selection of materials and in other convenient ways, the general influence of silicon can be utilized to render the cast iron suitable to various purposes, but it must be used with due regard to the other constituents of the metal.

7 *Sulphur.* The influence of sulphur is opposite to silicon, in that it makes the iron harder and more brittle. It makes the iron more sluggish when pouring and is liable to cause unsound castings. Sulphur increases shrinkage, resulting in internal stresses of unknown value and sometimes producing distorted castings. This element should be kept low, especially in small castings.

8 *Manganese.* One effect of manganese is to combine with sulphur and go off in the slag. Another is to retard the separation of graphite by combining with carbon, and in this its influence is opposite to that of silicon, rendering the iron harder, stronger and perhaps closer.

9 *Phosphorus.* Phosphorus lowers the melting point and increases the fluidity of the molten iron. On the other hand, phos-

phorus makes the casting harder, more crystalline and brittle, and reduces the tensile strength.

SPECIAL MIXTURES

10 *Semi-Steel.* This mixture is obtained by charging mild steel scrap into the cupola. It is common practice to use about 20 per cent steel, but any amount up to 70 per cent may be used. The 20 per cent mixture usually gives the desired results for machine-tool work. Semi-steel is lower in total carbon than cast iron, seldom having more than 3 per cent. The fine grain of semi-steel is due to low percentage and fineness of graphite. It is used for parts requiring good appearance, tensile strength, and ability to resist shock. It is often used for large gear blank castings for various machine tools, for milling-machine tables, knees, and saddles, for lathe reverse plates, compound rests, etc. Tensile strength is relatively high and the grain of the casting is close.

11 *Alloys.* Elements sometimes introduced into cast iron for special purposes are vanadium, titanium, nickel and chromium. Vanadium increases the ability of the casting to resist wear. Titanium combines with nitrogen and goes off in the slag, thus acting as a scavenger and making closer and cleaner iron. While nickel and chromium are now used to a limited extent in heavy chilled castings such as car wheels and rolling-mill rolls, the writer has been unable to find instances of the use of these metals in cast iron for machine-tool parts or for similar purposes. Their use might be desirable for special castings as it would doubtless increase the strength. But for machine-tool work the additional expense of such alloy castings might not be warranted, as today all parts where high tensile strength is required are made of steel.

MIXTURES USED BY REPRESENTATIVE MACHINE-TOOL MAKERS

12 In the belief that valuable information could be secured by a comparison of the present practices of representative machine-tool manufacturers, the writer asked a number of machine-tool makers in different lines and in different sections of the country if they would be willing to submit an outline of their practice. The following excerpts pertaining to the mixtures used and chemical analyses of the castings are quoted from their replies:

13 *A Builder of Special Machine Tools:* Our iron is bought on analysis specifications, covering two grades as follows:

TWO PLAIN

Silicon	1.75 to 2.25
Manganese	0.60 to 0.90

Phosphorus	0.50 to 0.80
Sulphur	0.05 and under
No. 3	
Silicon	1.00 to 1.50
Manganese	0.50 and over
Phosphorus	0.50 to 0.80
Sulphur	0.07 and under

In addition to the above we use materials as follows: No. 1 machinery scrap, mild steel scrap, manganese steel scrap. The last carries 12 per cent of manganese with quantities of the other elements so small that they are negligible in gray iron foundry work.

14 Our mixtures are figured out on the actual analysis of each car, insuring in the castings uniformity of analysis and consequently of physical characteristics, such as strength, density, and machining qualities. In general practice we use three different mixtures suited to our varying needs.

15 In our first mixture we include our lighter castings such as pulleys, small gears, washers, hand-wheels, brackets, and the like. In this mixture we endeavor to have the following analysis:

Silicon	1.90
Manganese	0.60
Phosphorus	0.70
Sulphur	0.08

This is usually secured by the use of a mixture of 50 per cent of two or three lots of two plain iron and 50 per cent of scrap. The proportions of the different pig irons are adjusted to produce the proper analysis in the mixture, and the scrap is partly our own foundry return and the balance No. 1 machinery scrap.

16 Our second mixture covers all our heavy work, such as planer beds, posts, tables, face plates, frames, etc. These castings require strength and sufficient density to permit the machined surface to take a high polish. These ends we accomplish by an analysis as follows:

Silicon	1.40
Manganese	0.60
Phosphorus	0.60
Sulphur	0.09

This mixture consists of 45 per cent of two or more No. 3 irons and 55 per cent total scrap, shop and No. 1 machinery together. Should this mixture fail to yield sufficient manganese the addition of 1 to 2 per cent of manganese steel scrap is made to correct it.

17 The third mixture is semi-steel, used principally for large blank gears and castings requiring special strength. Its analysis is

Silicon	1.20
Manganese	0.90
Phosphorus	0.45
Sulphur	0.09

Its average makeup is

	Per Cent
Machinery scrap	30
Mild steel scrap	20

Manganese steel scrap............................	5
No. 3 pig iron..	45

18 The above mixtures cover our entire range of work except cases where some special composition is required or desired.

19 All materials are weighed before charging into the cupola and all due precautions are taken to insure proper melting conditions and perfect mixtures of the various materials entering into each charge.

20 *A Manufacturer of Precision Machinery:* In our work we run various grades of iron to meet the conditions existing in the machines or in the parts of machines under consideration.

21 In a general way our mixtures, in per cent, run as follows:

Silicon	Manganese	Phosphorus
3.00	0.60	0.80
2.40	0.65	0.70
2.00	0.65	0.60

The first is for the average run of castings of smaller size; the second for the larger castings. Where we need a special close-grain iron we use the third mixture.

22 *A Manufacturer of Milling Machines:* We have never carried on any extensive experiments to learn the best mixtures of cast iron for our purposes. We use in the tables, knees, saddles and vises about 20 per cent of steel with a view to obtaining a close-grain casting, and increasing somewhat its strength.

23 We use practically no cast iron for gears or small parts, these being made of steel drop forged in the case of larger parts, and also in the case of smaller parts when not adopted for manufacture from the bar.

24 The subject of gray-iron castings is, we believe, one of the most annoying to be found in connection with the manufacture of machine tools. Customers are not satisfied to accept machines with defective castings even though the deficiency is of such a nature as to, in no wise, impair the life or efficiency of the machine.

25 The ideal casting is, of course, one that is so close as not to show any grain when finished and at the same time, just as hard as it can be, and be worked into shape.

26 The question of strength is probably not so important, as there is opportunity to use sufficient bulk to obtain strength. At any rate this is true of the parts that we make of cast iron, for, as stated above, all our gears and like parts are made from steel which is casehardened.

27 *A Manufacturer of Heavy Lathes:* With the heavier castings we are using a semi-steel mixture with about 20 per cent of steel. The analysis of this iron shows 1.60 to 1.70 silicon, 0.65 to 0.75 manganese, 0.40 phosphorus, 0.8 to 0.10 sulphur. While our carbons are not noted as a rule, we get a check on these every once in a while, showing the total carbons about 3.50 to 3.60.

28 Our iron for smaller pieces runs from 1.80 to 1.90 in silicon, 0.40 to 0.50 in phosphorus, 0.65 to 0.70 manganese, 0.07 to 0.10 in sulphur. The total carbon shows up practically the same in both mixtures. Our test bars on the first mixture break at from 2800 to 3200 and on the latter mixtures at about 2600. This refers to 1 in. by 1 in. standard bars supported on 12 in. centers.

29 *A Manufacturer of Grinding Machines:* We use castings with various proportions of steel according to the size of the casting and the place where it is to

be used, so that today we have very bright lustrous surfaces and it is possible to get accurate alignment.

PRACTICE WITH REFERENCE TO CHILLING CASTINGS

30 There is a wide difference of opinion among machine-tool manufacturers as to the desirability of chilling any surfaces of castings. The writer asked some of the representative manufacturers of various classes of machine tools for their experience on this point. The following quotations from their replies state both sides of the case:

31 *A Manufacturer of Milling Machines:* We are not using any chills at this time, though we have experimented with these from time to time but have reached no satisfactory conclusion.

32 *A Lathe Manufacturer:* We have not used chills on any parts of our machines, which, we must concede, is from many points of view, not a very satisfactory admission to make.

33 *A Manufacturer of Heavy Machine Tools:* For quite a period, about nine or ten years ago, we chilled the ways on our lathe and also the rails on our boring mills. We found, however, after they had been out some time that there was quite a bit of trouble with the chilled surfaces scratching. It was hard for us to find exactly what was the root of the trouble and we finally gave it up. The effect of the scratching of the chilled ways was a most peculiar one, and we sometimes observed on a machine even before it had gone out that some little particle of material had settled on the way and scratched the same badly.

34 *A Manufacturer of Grinding Machines:* In regard to chilled iron, of course, you know that chilled iron means this and nothing else: It means iron that cannot be filed, planed or scraped. At least any mechanic who hears the words "chilled iron" understands it to mean just that thing, a surface that cannot be cut with tools. Now, of course, you realize that such a surface makes it impossible to get practical aligning ways on machine tools. It might just barely be possible to grind them accurately, but probably not practical to do so. We use an iron with steel mixture, and vary the mixture according to the size of the casting, and we produce a casting as dense and as hard as we can possibly plane and scrape with any surety of getting perfect alignment, because imperfect bearing and imperfect alignment is just as bad and just as sure an error as iron that would be too soft. In fact if one had iron that was exceedingly soft, and should choose to make ways which are very wide it might be more durable than one made with hard iron and smaller ways.

35 *Another Manufacturer of Grinding Machines:* The main reason for chilling the different parts of our work is to increase the wearing durability and at the same time get the advantage of refining the metal and a clean surface. The parts chilled are the guides of the carriage and the surface of the table upon which the head and tailstocks are mounted.

36 Our method of chilling is to place plates of ⅝ in. in thickness in the mold, and these give a depth of chill of about ½ in. and a degree of hardness just to the point of where the machining can be readily done.

37 It would be natural to suppose that this chilling would produce or increase internal strains, but on our work, such conditions have not given any trouble.

38 Our work is not of such a nature where hammering upon it or peening is necessary. Therefore, we are unable to state just what action would take place as the result of hammer blows and peening.

39 The chilled surfaces are very much more durable than metal in the ordinary condition, and we believe by the chilling process the durability of the surface upon which wear comes is increased at least from 300 to 400 per cent.

40 *A Builder of Heavy Machine Tools:* In 1888 we began the practice of solidifying cast-iron surfaces by introducing chill blocks in the molds, and we have continued the practice ever since.

41 Answering your questions specifically, first, we have not discontinued the use of chilled surfaces because of any difficulty in oiling. We have never found that the fine grain of the chilled iron prevented the oil from sticking. There is no truth in the statement.

42 We have not found any increase in internal strains due to the use of chills. On the contrary, when chills are properly placed they equalize the cooling of the heavy parts adjacent to lighter portions and reduce the internal stresses which would naturally result from the difference in time of cooling. If the chills are improperly used it would be possible, especially in thin castings, to cool the entire mass too rapidly and produce internal stresses.

43 We have not found that the proper use of chills makes the iron more sensitive to a peening action; in fact, we have evidence to the contrary.

44 The chilled surface we believe to be more durable. We have cases where gearing made in this way outlasted several sets made in the old manner.

45 The success or failure of this process depends upon the ability to produce, day in and day out, the kind of metal required, and, further, the intelligent designing of chills of iron molds so that a proper relation may always be observed between the size and shape of the casting and the thickness of the mold or chill block.

46 *A Boring-Mill Manufacturer:* We are chilling certain surfaces on our boring-mill spindles with good success, but have found no occasion for chilling any other surfaces. If we experienced difficulty due to undue wear on sliding surfaces, we would increase the area of the surfaces and supply better lubrication and protection from dirt rather than to try to chill the surfaces of these parts.

47 The chills which we use on our spindles serve two purposes: first, by securing closer grained metal; second, by improving the quality of the wearing surfaces. We found that it was difficult to get good castings of these spindles until we did use chills.

48 *A Builder of Special Machine Tools:* Concerning chills, we would say that to some extent we are now using these on the surfaces of beds and similar castings.

49 *A Manufacturer of Precision Machinery:* We use such chills as may be necessary to give the surface in connection with the ways and moving parts.

CHILLED LATHE BEDS

50 *Analysis of Iron.* In view of the considerable differences in opinions of the value of chilled surfaces and the idea held by some that it is impossible to chill an iron of high tensile strength without making it so hard it cannot be machined, the practice of The Lodge

& Shipley Machine Tool Company, with which the writer is connected, is here outlined.

51 Three average analyses are as follows:

Silicon	Sulphur	Phosphorus	Manganese	Tensile Strength
2.16	0.065	1.01	0.40	22,310
2.17	0.065	1.01	0.39	24,840
2.45	0.076	0.63	0.71	24,195

The first analysis is of a specimen taken in January 1913 from the first iron run in a heat; the second, from the last iron of the same

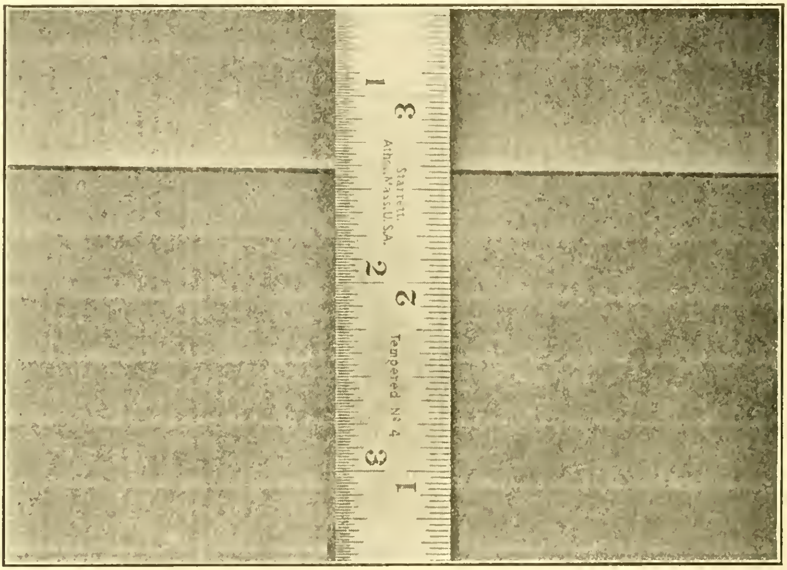


FIG. 1 CHILLED CASTING, FINISH PLANED BUT NOT SCRAPED

heat; the third, from the average iron of a heat in September 1913.

52 This same iron is used for lathe beds of which the ways are chilled, also for other cast-iron parts which do not require the high tensile strength of semi-steel. For some parts, such as compound rest top slides and reverse plates, we use semi-steel. Parts subject to greater stress or to severe shock are made of steel.

53 *Appearance of Chilled Surface.* A portion of the finished way of the lathe bed as it comes off the planer and before scraping is shown in Fig. 1. A steel scale is laid on the surface to indicate the closeness to actual size with which this is reproduced. A comparison with the 1/64 in. graduations on the scale shows the extremely close even grain of this chilled surface.

54 The exact effect of the chill on a casting is well illustrated in Fig. 2. This shows the cross-sectional fracture through the finished ways and a portion of the side wall of the chilled bed for a 30-in. lathe. The reproduction clearly shows that the iron even far away from the chill in the side wall of the casting is dense and of as close grain as other good cast iron; it also shows the much closer grain of

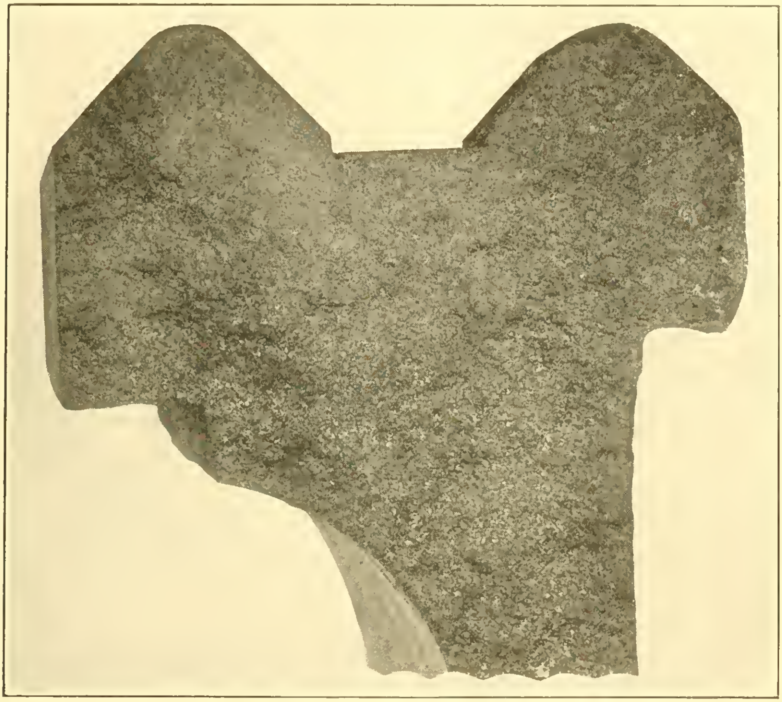


Fig. 2 Cross-Sectional Fracture of Chilled Lathe-Bed

the iron below the finished surface as a result of the chill in closing up the iron and making it harder and more durable. In the 30-in. bed, as plainly shown by this specimen, the close iron produced by the chill extends to a depth of $1\frac{1}{2}$ in. to 2 in. below the finished surface of the ways, thus proving that the chilled iron is not all removed in the planing.

55 *Degree of Hardness.* Scleroscope test on chilled beds finish planed but not scraped gave as a result of eight different tests on four different beds, scleroscope readings of 40 to 42 with an average of 41. Similar tests on chilled beds which had been planed and then

scraped gave a practically constant scleroscope reading of 42. Comparative scleroscope tests on a heavy section of unchilled cast iron which would give as nearly as possible conditions parallel to those just quoted gave readings ranging from 18 to 22, with an average of 20.

56 These tests indicate that the chilled ways are twice as hard as the unchilled. The same is also shown by the planing speed, as we can only plane the chilled beds at a trifle less than half the cutting speed formerly used.

57 In addition to the advantage gained by the hardness, the chilled beds are if anything more uniform than the unchilled. The rough beds as received from the foundry are quite straight, so that the amount of metal removed all along the ways in planing is as nearly uniform as is practicable. Then, too, the scleroscope readings indicated a more nearly constant degree of hardness on the chilled beds than on the unchilled. Fewer castings are unsound than before chills were used.

58 *Action of the Chill.* The chilled surface is produced by a series of cast-iron chill plates each about 6 in. long placed end to end in the mold. The use of separate short plates eliminates much of the warping and twisting which would occur in a long chill plate.

59 If a thick chill plate is used with a low-silicon iron the surface of the casting is chilled so hard that it cannot be machined. The desired result is attained by regulating the thickness of the chill plate to suit the size of the casting for which it is used; then a low-silicon iron of high tensile strength can be successfully poured. The heavier the casting, the thicker the chill plate.

60 The action in the mold is that when the molten iron strikes the cold plate it is chilled and hardened; then the heat in the mass of iron forming the body of the bed casting gradually warms the chilled surface and the chill plate, thus annealing the casting or "drawing the chill," just as when in tempering a chisel the heat in the shank of the chisel "draws the temper" of the cutting edge to the proper point after the cutting edge has been hardened by quenching in water. This annealing of the chilled surface of the casting produces the desired form of hard, close-grained gray iron.

61 The thickness of the chill plate used is such that the heat in the casting will anneal the surface sufficiently to permit planing, although at a greatly reduced cutting speed, and yet retain the benefits of the chill.

VALUE OF CHILLED SURFACES

62 The advantages of chilled wearing surfaces for machine tools are:

a Much harder surfaces, which experience has proved are vastly more durable than similar unchilled surfaces.

b A hard guiding surface with a relatively soft carriage, bringing the bulk of the wear on the carriage and thus maintaining the alignment of the guide.

c A denser and much more closely grained surface of the casting, giving better appearance.

d An exceptionally smooth finished surface, in which there are no pores where dirt and grit may become imbedded to cause rapid abrasion of the other bearing surface.

63 There are several ways of increasing the durability of working parts, such as by increasing the area of the bearing, by providing more complete lubrication, and by hardening the surfaces. All are successfully used. In general, each method may be used independently of the others. If the areas of the surfaces are as large as special conditions permit, and if the lubrication is thoroughly efficient, there would seem to be no objection to still further increasing the durability by the use of chills.

64 Chilled surfaces are more advantageous on some machines and some parts than on others. In the case of a lathe the carriage will often be used for long periods of time on chuck work or on short jobs between centers which brings all of the wear on a comparatively short length of the bed just in front of the headstock; such uneven wear on the unchilled bed destroys the accuracy of the alignment for long work. Chilling the ways brings the wear principally upon the carriage, and even if the carriage is worn, the alignment at all points along the bed will remain relatively true.

65 Only one manufacturer (see Par. 33) of all who were kind enough to reply on this subject had discontinued the use of chills; the others who are using chills do not report any trouble due to scratching. The objections to the use of chills aside from the one instance quoted, have come from foundrymen who do not and have not used chills.

66 Our own experience, based on the use of chilled ways on beds of all sizes of our lathes for more than two years, is that no internal stresses are created by the chilling; that the surface is not made more susceptible to a peening action; that the surface can be equally as well lubricated as before; that iron of high tensile strength is used;

and that the increased hardness and closeness of grain of the chilled surface vastly increases the durability and permanency of alignment. We find no disadvantage except a somewhat increased cost.

TENSILE STRENGTHS OF VARIOUS IRONS

67 As the letters received from other machine-tool manufacturers do not state tensile strengths, the following statements regarding the general practice of Cincinnati manufacturers are quoted:

68 *A Professor of Mechanical Engineering and Testing:* I believe the general Cincinnati machine-tool practice for good castings runs from 22,000 to 24,000 lb. per sq. in. tensile strength, but owing to the great variety I would not wish to commit myself to any particular figures.

69 *A Cincinnati Chemist:* After tabulating the results of my tests of the tensile strength of cast iron from various sources, I pick some at random to show the average run of machine-tool iron in lb. per sq. in. in this locality: 22,962; 24,090; 24,522; 23,197; 23,260.

70 This will give an idea of what the general run is. Good machineable iron, where the grain does not have to be too close for machine-tool work, should run from 20,000 to 26,000 lb. per sq. in. Low tensile strength is due to too much silicon, sulphur, or phosphorus.

CONCLUSIONS

71 Chilled surfaces for certain parts are desirable. There might be a limited field for special alloy castings and if any machine-tool manufacturers have experimented with them, the results of their tests would be welcome. There is a wide difference in the chemical analyses of irons used by representative manufacturers—this last circumstance may be due to the different melting conditions in the several foundries; or it may indicate a field where much good could be accomplished by a more complete interchange of information, and by experiments to determine the best mixtures for different purposes.

GEARS FOR MACHINE-TOOL DRIVES

By John Parker

ABSTRACT OF PAPER

This paper deals with the important subject of selecting the proper material for gears in accordance with the best modern machine-tool practice. The method of heat treating and hardening steel gears is fully explained, and the proper hardness by the scleroscope test for the different stages is given.

GEARS FOR MACHINE-TOOL DRIVES

By John Parker, Providence, R. I.

Member of the Society

The basis of this paper is the consideration of the following six questions relating to the use of gears for driving machine tools:

1 Under what conditions is it advisable to use cast-iron or steel gears for machine-tool drives?

2 Are the objections to cast-iron on the ground of wear or breakage?

3 What tooth pressure is safe for cast-iron gears?

4 What grades of steel give best results and how should they be treated?

5 How hard is it advisable to make steel gears before machining them?

6 Are they to be hardened after machining, and if so, to what scleroscope test?

2 *Conditions under which it is Advisable to use Cast-Iron or Steel Gears for Machine-Tool Drives.* There are a number of well established gear conditions that are common to the majority of machine tools, which if noted may prove somewhat of a guide in selecting the proper material for the gears, considered from the standpoints of economy, efficiency, and durability. The conditions may be classified, as in Table 1.

3 *The Objections to Cast Iron.* The objections to cast iron cover both wear and breakage. If the speed is excessive, say above 500 ft. per minute, they are likely to wear quite rapidly; and on slow speeds and heavy pressure breakage will occur, unless they can be made of adequate size, as in the case *E*, where the back gears are so located in the machine that it is possible to employ large diameters, coarse pitches, and wide faces.

4 *The Safe Tooth Pressure for Cast-Iron Gears.* The question of tooth pressures in cast-iron gears is somewhat problematical. The

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

TABLE 1 GEAR CONDITIONS COMMON IN MACHINE TOOLS

			Material
A	Gears always in mesh, the wear on the teeth being constant	(a) Slow speeds, light duty (b) Slow speeds, heavy duty (c) Fast speeds, light duty (d) Fast speeds, heavy duty	Cast iron Machinery steel Machinery steel Machinery steel, casehardened
B	Gears in sets that are removable and interchangeable with each other, distributing the wear over a number of gears	These are change gears used in thread cutting on lathes, spiral cutting on milling machines, indexing on automatic gear cutters and feed and speed change gears; speeds and pressures are generally moderate	Cast iron, excepting the smallest, which may require to be of steel
C	Gears in sets that are nonremovable and partially interchangeable, distributing the wear over a number of gears. Changes made while gears are in motion [1]	Used as quick-change feed gears—changes made by levers; speeds and pressures moderate	Machinery steel, casehardened
D	Gears in sets that are nonremovable and partially interchangeable, distributing the wear over a number of gears. Changes made when gears are at rest [2]	Used as quick-change speed gears—changes made by levers; high speeds and heavy pressure	Machinery steel, casehardened
E	Gears that are employed only part of the time the machine is working, and are engaged and disengaged when the machine is stopped	This condition applies to back gears for the spindle drive. Gears are made large diameter, coarse pitch and wide face; speeds moderate and heavy pressure	Hard, close-grained cast iron

[1] If the changes were made when the machine was at rest, the gears would not require hardening. But custom demands that changes be made while the machine is running.

[2] Although the changes are supposed to be made when gears are at rest, careless workmen will violate this rule, with the possibility of breaking the engaging gears. Some makers use an alloy steel in their spindle train to prevent breakage, but a better way is to provide means whereby it is necessary to stop the machine before throwing in the gears. This applies to the tumbler type of change gearing.

Brown & Sharpe Manufacturing Company have in successful operation a gear in the spindle drive of their largest milling machine made from a hard, close-grained cast iron having a tensile strength of 23,000 lb. per sq. in., which when running at the slowest speed sustains a pressure on the teeth of 8250 lb. It is calculated that two teeth are always in contact, which gives 4125 lb. pressure per tooth. The area in cross-section of each tooth is $1\frac{1}{4}$ sq. in., equaling 3300 lb. per sq. in.; when the gear runs at the fastest speed the pressure is about 1000 lb. per sq. in. It is not known whether the pressure could be increased to any considerable extent, but it has been overloaded to at least 30 per cent without injuring it; this was when testing out the machine and the overload was of short duration. It might be said that this gear is not subjected to any sudden shock; if it were, the allowable tooth pressure would be considerably less.

5 *The Grades of Steel that have given Best Results and how They have been treated.* For gears that are of small proportions and yet are subjected to heavy duty, it has been found that in cases where the more common steels have failed, excellent results have been obtained from using a 5 per cent nickel steel. This steel casehardens with a very hard surface and still has a strong and tough core, making it an ideal steel to use where the pressure is heavy or the gear is subjected to shock. Experience shows that drop forgings are more uniform in texture than bar stock. This grade of steel is given an oil treatment and is also annealed before machining; the oil treatment is as follows: heat to 1550 deg. fahr. and quench in oil. To anneal, reheat to 1350 deg. fahr. and cool very slowly. It is then ready to machine.

6 After machining, it is carbonized as follows: pack in any good carbonizing material and cover very carefully to exclude air, place in furnace and heat to 1700 deg. fahr., and hold long enough to get the desired depth of casing. Care should be taken to have it heated entirely through. Ordinarily three to four hours will suffice for this process. Then take out of furnace and cool off in the boxes; remove from the boxes and place in furnace or bath; reheat to 1550 deg. fahr. and quench in oil. Again reheat to about 1380 deg. fahr. and quench in oil or water according to the size and shape of gear. If the gear is of generous dimensions and free from sharp corners, water is preferably used. Small slender gears are quenched in oil, on account of the liability of cracking if water is used. For ordinary gears the scleroscope test should show 80 to 85 points of hardness. If the gears are used as clash gears they should be drawn to 475 deg. fahr., or about 70 to 75 points of hardness, by scleroscope test, to avoid chipping.

7 *Degree of Hardness Advisable for Steel Gears before Machining Them.* The various kinds of steels used for gears are of such a nature that they do not call for treating before machining, but where extra toughness in shafts is required to withstand torsion and bending strains, $3\frac{1}{2}$ per cent nickel steel is very satisfactory. This grade of steel is rough machined, then heat treated, as follows: place in open furnace or bath, heat to 1500 deg. fahr., and quench in oil. It is advisable to experiment with a small quantity in each batch before subjecting a whole lot to the drawing out heat, which should commence at about 700 deg. fahr. If the scleroscope registers between 50 and 58, the correct hardness has been obtained; if higher than 58, the parts should be reheated to a higher temperature than before; if lower than 50, the parts must be rehardened. After this treatment, the pieces are finish machined. No further hardening is necessary. When machining, slow speeds and feeds must be used.

8 *Hardening After Machining, and the Scleroscope Test.* Practically all alloy steels and all low-carbon steels are hardened after machining and finished by grinding after hardening. About 0.010 in. on the diameter is left for this operation. All gears should run true, and to obtain this result not only are the holes ground true with the pitch circle, but the hubs are ground on their faces so they will set square with their shafts when tightened up by nuts. The scleroscope test for 30 to 35 point carbon machinery steel is anywhere from 80 to 90, and for 5 per cent nickel steel for ordinary gears 80 to 85, and for clash gears 70 to 75. All steels are tested by the file in addition to the scleroscope. The file test by an expert is very reliable and some feel that possibly more confidence can be placed on his judgment than on any testing instrument.

9 The above notes apply to spur and bevel gears. For worm and worm-wheel drives, the worm should be made of machinery steel, casehardened, and the wheel of a hard bronze. Both should run in a bath of oil, especially if under high speed and heavy duty. Spiral gears should be used only where the duty is light. The material should be the same as for a worm and wheel, and they should also run in oil to avoid cutting.

10 For index mechanisms, where accuracy is essential, if the worm is hardened the thread must be ground afterwards. This is done in all the spiral heads of Brown & Sharpe's make. Generally, the worm, made of tool steel, is left soft. Worm wheels used for indexing purposes only are usually made of cast iron, and invariably if of large diameter. High-multiple threaded worms for indexing mechanisms should not be used; a double thread can be tolerated, but not more, if accurate indexings are required.

APPENDIX

A letter embodying the six questions set forth in Par. 1 of the paper was sent out by the Committee on Machine Shop Practice to various machine builders, and the following replies were received:

J. B. Doan.[1] Nearly all the gears used today in machine-tool construction are of cast iron, although the quantity of steel gears is increasing. The American Tool Works Company use cast iron with slow peripheral speeds and comparatively large diameters; steel for small diameters and high speeds, hardening those which experience teaches need such treatment.

The main objection to cast-iron gears is their breakage, and not so much their wear. A good grade of cast iron shows very good wear. A great many steel pinions are used, some of them hardened, working with cast-iron gears of large diameter, the difference of material compensating in strength for the weakness of the pinion tooth, and also for the wear occasioned by the different number of teeth.

The Lewis formula is used by The American Tool Works Company for tooth pressures on cast-iron gears.

For hardened-steel gears the following method with special gear stock made of very low carbon is employed: The gear is machine finished with an allowance of 0.012 in. on the bore for grinding after being heat treated as follows:

- *a* Pack in round cast-iron box, using 10 per cent charred leather, 40 per cent burnt bone, 50 per cent raw bone
- *b* Seal top with mortar of iron filings and fire clay about 1 in. thick
- *c* Cover with cast-iron lid and lute with clay
- *d* Heat for nine hours to 1560 deg. fahr.
- *e* Remove box from furnace and cool without disturbing contents
- *f* Remove pieces and heat to 1550 deg. fahr. in furnace
- *g* Quench in fish oil
- *h* Draw in tempering oil to 475 deg. fahr.

Gears are hardened after machining and tested with the scleroscope to 80.

J. B. Green. Gearing for machine tools is one of the interesting problems in connection with their design and construction. The selection of suitable materials for gears is usually fixed by the character of the machine and its uses. Some machines permit the use of large dimensions, while in others the sizes are often very limited.

The Lewis formula with the modifications made by Carl G. Barth as given in the American Machinist Gear Book, Pages 57 and 58, is the well beaten path usually followed in selecting the best materials for gearing, and when properly used, there is a reasonable field of uses for all materials.

Cast iron can be used in all places where there is sufficient room for the proper dimensions and, when not overloaded, the teeth wear to a polished and glazed

[1] Vice-President and General Manager, The American Tool Works Company, Cincinnati, Ohio.

surface so characteristic of this material. When slightly overloaded, the wearing surface of the teeth becomes crushed and cut at the pitch line and then wears out very rapidly; when considerably overloaded, failure occurs through breakage.

Steel iron, or semi-steel, as it is sometimes called, is made of a mixture of steel and cast iron and when made of the proper proportions, is a very good improvement over cast iron, being strong enough to carry about 50 per cent more load and giving very similar results in regard to wear and breakage.

Low-carbon steel gears will carry from two to two and a half times the load for cast iron; when slightly overloaded they wear a line depression across the face of the teeth at the pitch diameter and when continuously overloaded soon wear out.

Steel gears containing about 20 per cent carbon can be casehardened after being machined; when so treated they will stand considerable use without wear and are especially valuable for pinions meshing into large gears.

The high-carbon and alloy-steel gears will stand loads proportionate with the permissible stresses for the various materials. These steels may be heat treated before machining which will allow large pieces to be greatly toughened and strengthened and then finished to the required accuracy, whereas, if the same pieces were hardened after machining, the resulting distortion would make such an operation impossible.

When the nature of the piece will permit, the alloy steels may be hardened throughout when all machining is completed and then drawn to the proper temper so as to make an almost indestructible gear. The exact hardness or toughness of teeth must be determined by the uses for which the gear is intended and in many cases experiments are necessary.

E. A. Muller. If cast-iron gears were inadequate for their purpose, I should be the first to discard their use. In view, however, of the most excellent results obtained with them, such a move would not be warranted, especially when the substitution of heat-treated alloy-steel gears would simply increase the cost of a machine.

If a large amount of mechanism subjected to heavy loads must be placed in a small compass the cast-iron gear is unequal to the requirements, but in many machine tools much space is available for the driving gears and there is really no excuse for adding to the cost of these machines by designing the equivalent of automobile transmission gears for machine-tool drives.

Since 1893 I have used Wilfred Lewis' formula for safe working pressure on gear teeth with uniformly excellent results. Neither wear nor breakage has been objectionable; in fact, gears in use six years on machines in hard service show no appreciable wear. Cast-iron gears and steel pinions proportioned in accordance with the Lewis formula should not exceed 1200 ft. pitch line velocity. Experience with gears designed by this formula indicates that cast-iron gears can transmit greater horsepower without failure, but that wear begins to increase considerably as the load increases.

The King Machine Tool Company do not use heat-treated or hardened-steel gears at all. In such machinery where ample space is provided for gearing, I do not believe that properly proportioned cast-iron gears and steel pinions can be improved upon. However, where conditions obtain as in automobile transmissions, heat-treated and hardened-steel gears are indispensable.

Another machine builder writes: We find that cast-iron and mild-steel gears

work very satisfactorily for machine-tool drives wherever there is room enough to make them of the proper size to avoid extreme wear. This is particularly true where the gears can run in oil. In general, of two sets of gears of the same dimensions, running under the same load, at the same speed, the one made of unhardened steel will run more smoothly than the one made of hardened steel. The question of hardened versus unhardened gears is therefore one of space and weight limitations. It should be noted that cast iron running with cast iron, or a steel pinion running with a cast-iron gear is a good combination, but that two mild steel gears running together, particularly at high speeds, should be avoided under any circumstances. The soft-steel gears abrade themselves with great rapidity.

The objections to cast iron are on the ground of liability to breakage in the case of work involving hammer blows or sudden or reversed stresses. There is no great objection from the standpoint of wear, where gears of the proper size can be used as indicated in the preceding paragraph, and where constant lubrication is provided.

For ordinary machine tool work we have found by experience that the Lewis formula, with the strength factors originally given, gives gears that are from 25 per cent to 40 per cent too strong.

Harder steels give better results from the standpoint of wear and abrasion as well as of strength. When it becomes necessary to use hardened gears, there is nothing better than to follow automobile practice closely, using chrome nickel or similar materials heat treated in the approved manner.

We should be inclined to anneal them as thoroughly as possible before machining in order to have the tooth surfaces cut as accurately as possible. At the same time, with the shaper tool of the gear shaper it is possible to machine gears for a finishing cut that are heat treated so hard that a file will barely touch them. This is done by several firms, using turpentine as a lubricant, with very good results.

We have found that the scleroscope test is unreliable, and that its indications show very little regarding the matter of hardness for resisting wear, particularly when trying to compare pieces of different shapes or methods of support. Some gear specialists have come to this conclusion also, while others use the instrument with more or less favorable results. We would appreciate further information on this point.

A RECORD OF PRESSED FITS

By C. F. MacGill

ABSTRACT OF PAPER

The paper presents a record of forced fits that have been made in actual practice on electric generators and motor shafts, together with table showing sizes, thickness of hub wall and material used, also formulae used in calculating tension stress, radial pressure and coefficient of friction.

A RECORD OF PRESSED FITS

By C. F. MacGill, St. Louis, Mo.

Member of the Society

Articles on forced or pressed fits have been published in various technical journals of the country during the past ten or twelve years, one by Stanley H. Moore[1] appearing in the Transactions of the Society. In but one of the papers noticed is there any reference to the diameter and length of the hub into which the shaft is forced or the material of which the hub is made, three very important elements in a forced fit. The great difference in allowances recommended, and in the pressures shown in the articles referred to, led me to have an exact record kept of each forced fit, from which were later calculated the tension stress, radial pressure and the coefficient of friction. Table 1 forming part of this paper is the result.

2 In my own experience, covering about 20 years, in charge of shops where forced fits were made, I have found that it was not necessary to increase the allowance with the diameter of the shaft, as the increased surface area of the fit added sufficient friction to bring the pressure up to the required tonnage, and that an allowance of from 0.002 in. to 0.004 in. on steel shafts pressed into steel hubs, and an allowance of from 0.003 in. to 0.005 in. on steel shafts pressed into cast-iron hubs of ordinary hardness, gave good results. I have yet to learn of one of these shafts coming loose.

3 There is no doubt in my mind that allowances greater than 0.006 in. on steel shafts pressed into cast-iron hubs, not only do not serve any useful purpose, but tend to set up strains that are injurious to the casting.

4 One large plant with which I am familiar issues an allowance table for pressed fits, the allowance gradually increasing with the shaft diameter. This is not followed in their shaft department, but instead a flat allowance of 0.003 in. is used without regard to the diameter of the shaft.

[1] Fits and Fitting, vol. 24, p. 1158.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

5 The allowances given by Mr. Moore, in his paper already referred to, are very much too great, while those given by Mr. Riddell[1] in his discussion of the paper are too low for sizes under 12 in.

6 According to Mr. Moore's formula $A = 2D + 0.5$ and shown in his table, the allowance for an 8-in. shaft would be $8 \times 2 + 0.5 =$ 0.0165 in., and on a 12-in. shaft $12 \times 2 + 0.5 = 0.0245$ in., and as, from Table 1 of actual fits, an allowance of 0.002 in. on 8-in. shafts pressed into steel hubs showed pressures of from 75 to 110 tons and an allowance of 0.004 in. on a 12-in. shaft pressed into a cast-iron hub showed 130 tons, it does not seem that greater allowances are either necessary or advisable.

7 The records in Table 1 cover 206 fits of diameters varying in size from 3.5 in. to 20 in., sufficient in range and number to demonstrate the correctness and value of the practice followed. All of these measurements and gage readings were taken by the same inspector, and as he was a thoroughly reliable man, I am satisfied that they are correct. The records are all of fits made on electric generators and motors.

8 The table shows the diameter of the shaft, the diameter of the bore, the length of the seat, the diameter of the hub, the material of which the hub is made, the allowance (the difference between the diameter of the shaft and the diameter of the bore of the hub into which the shaft is pressed), the pressure in tons required to force the shaft in, the maximum tension stress in the bore in pounds per square inch, the radial pressure on the surface of the shaft in pounds per square inch, and the coefficient of friction. These figures are given as a record of actual experience on sizes between the diameters shown. They are not claimed to represent correct practice beyond these dimensions.

9 In Table 1 the last three columns were figured from formulae developed by Prof. A. Morley and published in Engineering, August 11, 1911. In these formulae

R_1 = outer radius of hub

R_2 = inner radius of hub = radius of shaft after fitting

$A = R_1 - R_2$ = thickness of hub wall

$D = 2R_2$ = diameter of shaft

p_2 = radial compressive stress in lb. per sq. in. at radius R_2

f_t = hoop tension per sq. in. at radius R_2

J = excess in original diameret of shaft over that of bore of hub = allowance

[1] P. 1173.

E = Young's modulus for shaft material, assumed 30,000,000
E_1 = Young's modulus for hub material, assumed 15,000,000 } thus $E=2E_1$

$\frac{1}{m}$ = Poisson's ratio for shaft material
$\frac{1}{m_1}$ = Poisson's ratio for hub material } assumed $m=m_1=4$

Total tension stress at bore of hub

$$f_t=\frac{\frac{J}{D}\times E}{\left\{\left(\frac{m-1}{m}+\frac{1}{m_1}+\frac{E}{E_1}\right)\frac{R_1^2-R_2^2}{R_1^2+R_2^2}+\frac{E}{E_1}\right\}}$$

Normal pressure on surface of shaft

$$P_2=\frac{\frac{J}{D}-\frac{f_t}{E_1}}{\frac{m-1}{m\,E}+\frac{1}{m_1\,E_1}}$$

Coefficient of friction

$$\mu=\frac{P}{P_2}$$

where

P_2 = total normal pressure in tons
P = pressure in tons required to force shaft into hub

EXAMPLE RECORD NO. 84

Cast-iron hub on steel shaft $D=6.0025$ in., $J=0.0025$ in., length of hub $l=7$ in., thickness of hub $t=3\frac{5}{8}$ in. Assuming $m=m_1=4$ and $E=2E_1=30{,}000{,}000$, then

Max. tension stress $$f_t=\frac{\frac{0.0025}{6}\times 30{,}000{,}000}{\left(\frac{3}{4}+\frac{1}{4}\times 2\right)\frac{44-9}{44+9}+2}=4425 \text{ lb. per sq. in.}$$

Radial pressure $$p_2=\frac{\frac{0.0025}{6}-\frac{4425}{15{,}000{,}000}}{\frac{3}{4\times 30{,}000{,}000}+\frac{1}{4\times 15{,}000{,}000}}=2920 \text{ lb. per sq. in.}$$

$$\text{Coefficient of friction}=\frac{40}{\frac{\pi\times 6\times 7\times 2920}{2000}}=0.207$$

TABLE 1 DATA AND CALCULATIONS ON PRESSED FITS

Number of Record	Diameter of Shaft, In.	Diameter of Bore, In.	Length of Seat, In.	Diameter of Hub, In.	Material in Hub	Allowance, In.	Pressure, Tons	Maximum Tension Stress of Bore, Lb. per Sq. In.	Radial Pressure on Surface of Shaft, Lb. per Sq. In.	Coefficient of Friction
1	3.504	3.500	6	5	Steel	0.004	30	25520	8680	0.105
2	3.504	3.500	6	5	Steel	0.004	45	25520	8680	0.157
3	3.504	3.500	6	5	Steel	0.004	45	25520	8680	0.157
4	3.503	3.500	6	5	Steel	0.003	50	19185	6525	0.233
5	3.504	3.500	6	4½	Steel	0.004	30	27360	6840	0.133
6	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
7	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
8	4.004	4.000	6	6¼	Steel	0.004	40	21125	8875	0.120
9	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
10	4.004	4.000	6	6¼	Steel	0.004	40	21125	8875	0.120
11	4.003	4.000	8	5½	Steel	0.003	30	17175	5325	0.112
12	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
13	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
14	4.004	4.000	6	6¼	Steel	0.004	45	21125	8875	0.134
15	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
16	4.004	4.000	6	6¼	Steel	0.004	33	21125	8875	0.0985
17	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
18	4.004	4.000	8	5½	Steel	0.004	40	22900	7100	0.112
19	4.004	4.000	6	7¼	Steel	0.004	50	19545	10456	0.127
20	4.004	4.000	6	6¼	Steel	0.004	45	21125	8875	0.103
21	4.004	4.000	6	6¼	Steel	0.004	50	21125	8875	0.149
22	4.004	4.000	6	6¼	Steel	0.004	50	21125	8875	0.149
23	4.004	4.000	6	6¼	Steel	0.004	45	21125	8875	0.103
24	4.004	4.000	6	6¼	Steel	0.004	45	21125	8875	0.103
25	4.054	4.051	6	6¼	Steel	0.003	40	15915	6286	0.153

26	4.054	4.051	6	6¼	Steel	0.003	40	15915	6286	0.153
27	4.505	4.500	8	6½	Steel	0.005	60	24665	8665	0.122
28	4.505	4.500	8	6½	Steel	0.005	50	24665	8665	0.102
29	4.5035	4.500	8	6½	Steel	0.0035	45	17285	6050	0.131
30	4.505	4.503	6½	5¾	Cast Iron	0.002	20	5750	1455	0.3
31	4.503	4.500	6	10	Cast Iron	0.003	30	7070	4690	0.151
32	4.503	4.500	6	10	Cast Iron	0.003	30	7070	4690	0.151
33	4.503	4.500	8	6½	Steel	0.003	40	14815	5185	0.136
34	4.503	4.500	8	6½	Steel	0.003	40	14815	5185	0.136
35	4.880	4.875	7	7½	Steel	0.005	48	21885	8865	0.101
36	4.880	4.875	6	7¼	Steel	0.005	45	22365	8385	0.117
37	4.880	4.875	6	7¼	Steel	0.005	45	22365	8385	0.117
38	4.880	4.875	7	7¼	Steel	0.005	60	22365	8385	0.143
39	4.880	4.875	7	7¼	Steel	0.005	45	22365	8385	0.107
40	4.880	4.874	6	7¼	Steel	0.006	67	26835	10064	0.145
41	4.880	4.875	7	8	Steel	0.005	40	21060	9690	0.077
42	4.880	4.875	6	7¼	Steel	0.005	50	22365	8385	0.130
43	4.880	4.875	6	7¼	Steel	0.005	50	22365	8385	0.130
44	4.880	4.876	7	7¼	Steel	0.004	40	17890	6710	0.111
45	4.880	4.875	6	7¼	Steel	0.005	50	22365	8385	0.130
46	4.880	4.875	7	8	Steel	0.005	55	21060	9690	0.106
47	4.880	4.875	6	7¼	Steel	0.005	45	22365	8385	0.117
48	4.880	4.875	6	7¼	Steel	0.005	45	22365	8385	0.117
49	4.880	4.875	6	7½	Steel	0.005	45	21885	8865	0.113
50	4.880	4.875	6	7½	Steel	0.005	45	21885	8865	0.113
51	4.880	4.875	6	7½	Steel	0.005	45	21885	8865	0.113
52	4.880	4.875	6	7½	Steel	0.005	45	21885	8865	0.113
53	4.880	4.875	7	8	Steel	0.005	55	21060	9690	0.106
54	4.880	4.875	6	7¼	Steel	0.005	40	22365	8385	0.104
55	4.880	4.875	6	7¼	Steel	0.005	50	22365	8385	0.130

TABLE 1—*Continued*

Number of Record	Diameter of Shaft, In.	Diameter of Bore, In.	Length of Seat, In.	Diameter of Hub, In.	Material in Hub	Allowance, In.	Pressure, Tons	Maximum Tension Stress of Bore, Lb. per Sq. In.	Radial Pressure on Surface of Shaft, Lb. per Sq. In.	Coefficient of Friction
56	4.880	4.875	7	8	Steel	0.005	50	21060	9690	0.096
57	5.003	5.000	7¾	10	Cast Iron	0.003	25	6545	3930	0.105
58	5.003	5.000	8	10	Cast Iron	0.003	20	6545	3930	0.081
59	5.002	5.000	5½	7¾	Steel	0.002	50	8500	3500	0.330
60	5.440	5.437	9	13 3/16	Cast Iron	0.003	25	5730	4055	0.0806
61	5.440	5.437	9	13 3/16	Cast Iron	0.003	25	5730	4055	0.0806
62	5.502	5.500	8	13	Cast Iron	0.002	22	3800	2650	0.120
63	5.502	5.500	8½	13	Cast Iron	0.002	25	3800	2650	0.128
64	5.630	5.625	7	13	Cast Iron	0.005	30	9340	6390	0.076
65	5.630	5.625	7½	8¼	Steel	0.005	40	19550	7115	0.085
66	5.629	5.625	8¼	8¼	Steel	0.004	65	15640	5695	0.207
67	5.630	5.625	7½	8½	Steel	0.005	65	19185	7480	0.131
68	5.630	5.625	7	8	Steel	0.005	45	19900	6765	0.1075
69	5.630	5.625	7	8¼	Steel	0.005	65	19550	7115	0.148
70	5.630	5.625	6½	8¼	Steel	0.005	65	19550	7115	0.159
71	5.630	5.625	7	8¼	Steel	0.005	65	19535	7115	0.147
72	5.630	5.625	7	8½	Steel	0.005	55	19185	7480	0.119
73	5.630	5.625	7	9¼	Steel	0.005	48	18260	8405	0.092
74	5.630	5.625	7½	8½	Steel	0.005	50	19185	9480	0.101
75	5.630	5.625	7	8¼	Steel	0.005	55	19535	7115	0.125
76	5.630	5.625	8	8	Steel	0.005	55	20000	665	0.1185
77	5.7525	5.750	8	12¾	Cast Iron	0.0025	18	4610	3060	0.081
78	5.752	5.750	8	12¾	Cast Iron	0.002	20	3690	2375	0.117
79	6.005	6.000	8	9	Steel	0.005	70	18055	6945	0.134
80	6.002	6.000	8	9	Steel	0.002	55	7220	2780	0.262

81	6.003	6.000	7¾	13¾	Cast Iron	0.003	30	5265	3575	0.115
82	6.005	6.000	8	9	Cast Iron	0.005	30	10485	3225	0.123
83	6.003	6.000	8	14½	Cast Iron	0.003	40	5200	3680	0.144
84	6.0025	6.000	7	13¼	Cast Iron	0.0025	40	4425	2920	0.207
85	6.0025	6.000	8	14½	Cast Iron	0.0025	38	4425	2920	0.173
86	6.130	6.125	7	8¼	Steel	0.005	65	19065	5475	0.176
87	6.253	6.250	9	11½	Steel	0.003	60	19065	5475	0.134
88	6.253	6.250	9	11½	Steel	0.003	65	9320	5080	0.145
89	6.253	6.250	9	11½	Steel	0.003	65	9320	5080	0.145
90	6.2735	6.273	9	11½	Steel	0.0005	15	1550	8401	0.20
91	6.5025	6.500	8	21¾	Cast Iron	0.0025	40	3790	3170	0.155
92	6.503	6.500	8	14¾	Cast Iron	0.003	40	4871	3280	0.149
93	6.502	6.500	8	14¾	Cast Iron	0.002	38	3245	2190	0.213
94	6.503	6.500	6	12	Cast Iron	0.003	40	5160	2835	0.23
95	6.503	6.500	8	13½	Cast Iron	0.003	35	4980	3110	0.134
96	6.502	6.500	8	13	Cast Iron	0.002	25	3355	2115	0.152
97	6.503	6.500	8	11¼	Steel	0.003	90	9220	4610	0.24
98	6.5025	6.500	8	14¾	Cast Iron	0.0025	25	4060	2735	0.112
99	6.503	6.500	8	14¾	Cast Iron	0.003	35	4800	3395	0.126
100	6.502	6.500	12	10	Cast Iron	0.002	50	3680	1495	0.275
101	6.610	6.605	11	14	Steel	0.003	60	8000	5620	0.094
102	6.939	6.937	7¾	13	Cast Iron	0.002	15	3210	1785	0.1
103	6.939	6.937	8	11	Cast Iron	0.002	17	3410	1465	0.133
104	7.002	7.000	10	12	Steel	0.002	75	5730	2820	0.242
105	7.002	7.000	10	12	Steel	0.002	80	5730	2820	0.268
106	7.003	7.000	10	12½	Steel	0.003	90	8325	4515	0.181
107	7.002	7.000	9	17	Cast Iron	0.002	50	2965	2110	0.24
108	7.003	7.000	10	13	Steel	0.003	85	8285	4615	0.168
109	7.003	7.000	10	13	Steel	0.003	80	8285	4615	0.158
110	7.003	7.000	9	16¾	Cast Iron	0.003	40	4465	3135	0.129

TABLE 1—*Continued*

Number of Record	Diameter of Shaft, In.	Diameter of Bore, In.	Length of Seat, In.	Diameter of Hub, In.	Material in Hub	Allowance, In.	Pressure, Tons	Maximum Tension Stress of Bore, Lb. per Sq. In.	Radial Pressure on Surface of Shaft, Lb. per Sq. In.	Coefficient of Friction
111	7.002	7.000	10	12	Steel	0.002	95	5730	2820	0.307
112	7.003	7.000	8	12¾	Cast Iron	0.003	35	4815	2600	0.153
113	7.003	7.000	10	13	Steel	0.003	50	8285	4615	0.0985
114	7.0035	7.000	8	14¾	Cast Iron	0.0035	45	5375	3400	0.12
115	7.003	7.000	9	17	Cast Iron	0.003	50	4450	3160	0.18
116	7.003	7.000	8	12	Steel	0.003	100	8605	4235	0.269
117	7.034	7.031	8	10½	Steel	0.003	75	9260	3520	0.262
118	7.034	7.031	8	10½	Steel	0.003	35	9260	3520	0.113
119	7.1895	7.187	7	13	Cast Iron	0.0025	25	3915	2085	0.152
120	7.2525	7.2495	9	16¾	Cast Iron	0.003	35	4350	2475	0.115
121	7.437	7.435	7½	11	Cast Iron	0.002	25	3275	1220	0.234
122	7.4395	7.437	8	13	Cast Iron	0.0025	25	3810	1970	0.136
123	7.502	7.499	8	12¾	Cast Iron	0.003	55	4605	2230	0.238
124	7.5025	7.500	8	13	Cast Iron	0.0025	35	3810	1905	0.194
125	7.5027	7.500	8	14½	Cast Iron	0.0027	20	3970	2290	0.0925
126	7.5029	7.501	8	25½	Cast Iron	0.0019	15	2460	2145	0.074
127	7.534	7.531	10	12	Steel	0.003	50	8320	3620	0.117
128	8.002	8.000	9½	13¾	Steel	0.002	60	5015	2485	0.202
129	8.002	8.000	9½	13¾	Steel	0.002	60	5015	2485	0.202
130	8.002	8.000	9½	13¾	Steel	0.002	60	5015	2485	0.202
131	8.002	8.000	16	14	Steel	0.002	110	4975	2525	0.217
132	8.002	8.000	9½	13¾	Steel	0.002	80	5015	2485	0.27
133	8.002	8.000	9½	13¾	Steel	0.002	85	5015	2485	0.286
134	8.002	8.000	9½	13¾	Steel	0.002	75	5015	2485	0.253
135	8.002	8.000	9½	13¾	Steel	0.002	80	5015	2485	0.27

136	8.002	8.000	9	13½	Steel	0.002	80	5065	2435	0.318
137	8.003	8.000	9	17	Cast Iron	0.003	50	4025	2565	0.173
138	8.4395	8.4375	7	11	Cast Iron	0.002	25	3060	795	0.34
139	8.4395	8.437	8	11	Cast Iron	0.0025	18	3820	833	0.205
140	8.440	8.4375	8	11	Cast Iron	0.0025	15	3820	833	0.17
141	8.503	8.500	8	14¾	Cast Iron	0.003	35	4035	2015	0.162
142	8.503	8.500	8	14½	Cast Iron	0.003	45	4055	1980	0.212
143	8.503	8.500	9	15	Cast Iron	0.003	40	3815	2370	0.141
144	8.503	8.500	8	14¾	Cast Iron	0.003	45	4435	2020	0.208
145	8.5025	8.500	6½	15	Cast Iron	0.0025	30	3000	2255	0.154
146	8.505	8.5015	8	15	Cast Iron	0.0045	45	6005	3085	0.136
147	8.507	8.504	9	11	Cast Iron	0.003	40	4565	1145	0.292
148	8.564	8.562	14	13½	Cast Iron	0.002	30	2765	848	0.1875
149	8.939	8.937	8	13	Cast Iron	0.002	18	2860	762	0.211
150	8.939	8.937	8	13	Cast Iron	0.002	20	2860	762	0.234
151	8.939	8.937	8	13	Cast Iron	0.002	22	2860	762	0.257
152	9.002	8.999	12	20½	Cast Iron	0.003	65	3515	2375	0.161
153	9.002	8.999	12	20½	Cast Iron	0.003	65	3515	2375	0.161
154	9.0025	8.999	12	20½	Cast Iron	0.0035	75	4100	2375	0.159
155	9.0025	8.999	12	20½	Cast Iron	0.0035	75	4100	2375	0.159
156	9.0015	8.9995	9	16¾	Cast Iron	0.002	22	2480	1370	0.126
157	9.002	9.000	10	14	Steel	0.002	80	4710	1955	0.29
158	9.002	9.000	10	14	Steel	0.002	75	4710	1955	0.272
159	9.003	9.000	12	20¾	Cast Iron	0.003	70	3500	2395	0.171
160	9.003	9.000	12	20¾	Cast Iron	0.003	70	3500	2395	0.171
161	9.003	9.000	12	21	Cast Iron	0.003	70	3495	2410	0.171
162	9.003	9.000	12	20¾	Cast Iron	0.003	70	3500	2395	0.171
163	9.002	9.000	13	20½	Cast Iron	0.002	75	2345	1585	0.257
164	9.003	9.000	12	20¾	Cast Iron	0.003	90	3500	2395	0.22
165	9.003	9.000	12	14¾	Cast Iron	0.003	85	3890	1775	0.298

TABLE 1—*Continued*

Number of Record	Diameter of Shaft, In.	Diameter of Bore, In.	Length of Seat, In.	Diameter of Hub, In.	Material in Hub	Allowance, In.	Pressure, Tons	Maximum Tension Stress of Bore, Lb. per Sq. In.	Radial Pressure on Surface of Shaft, Lb. per Sq. In.	Coefficient of Friction
166	9.003	9.000	10	18⅜	Steel	0.003	100	6200	3795	0.187
167	9.003	9.000	10	18⅜	Steel	0.003	80	6200	3795	0.149
168	9.003	9.000	9	17	Cast Iron	0.003	45	3700	2080	0.17
169	9.003	9.000	9	17	Cast Iron	0.003	50	3700	2080	0.189
170	9.939	9.937	7½	13	Cast Iron	0.002	25	2745	720	0.295
171	9.9998	9.996	9	16¾	Cast Iron	0.0038	60	4400	2080	0.204
172	10.003	10.000	9	16¾	Cast Iron	0.003	40	3495	1640	0.172
173	10.004	10.000	12	21	Cast Iron	0.004	90	4205	2715	0.176
174	10.0035	10.000	14	21	Cast Iron	0.0035	80	3765	2375	0.153
175	10.002	10.000	12	18	Steel	0.002	55	3925	2475	0.128
176	10.502	10.500	8	13	Cast Iron	0.002	16	2505	550	0.22
177	11.002	11.000	12⅝	18	Steel	0.002	70	3750	1705	0.189
178	11.002	11.000	12⅝	18	Steel	0.002	80	2750	1705	0.216
179	11.005	10.9997	14	20¾	Cast Iron	0.053	38	5350	3005	0.0525
180	11.002	11.000	12¾	18	Steel	0.002	85	3750	1705	0.24
181	11.002	11.000	13½	18	Steel	0.002	90	3750	1705	0.227
182	11.002	11.000	13	18	Steel	0.002	90	3750	1705	0.235
183	11.002	11.000	13	18	Steel	0.002	70	2750	1705	0.183
184	11.002	11.000	12¾	18	Steel	0.002	90	3750	1705	0.24
185	11.002	11.000	13	18	Steel	0.002	100	3750	1705	0.261
186	11.0025	11.000	10	17½	Cast Iron	0.0025	50	2680	1160	0.25
187	11.0035	11.000	10	17½	Cast Iron	0.0035	60	2755	1625	0.214
188	11.064	11.062	12	18¾	Cast Iron	0.002	48	2100	975	0.236
189	12.004	12.000	12	20¾	Cast Iron	0.004	130	3815	1895	0.302
190	12.003	12.000	13	20½	Cast Iron	0.003	70	2875	1405	0.204

191	12.004	12.000	13	21	Cast Iron	0.004	78	3795	1930	0.165
192	13.0045	13.002	13	21½	Cast Iron	0.0025	100	2235	1035	0.362
193	13.003	13.000	14	22	Cast Iron	0.003	85	2660	1265	0.235
194	13.0045	13.000	12	22	Cast Iron	0.0045	90	4000	1905	0.193
195	13.0045	13.000	12	22	Cast Iron	0.0045	100	4000	1905	0.213
196	13.003	13.000	12	25½	Cast Iron	0.003	70	2530	1470	0.195
197	13.004	13.000	13	26	Cast Iron	0.004	100	3355	2015	0.187
198	13.0035	13.000	13	22	Cast Iron	0.0035	110	3105	1490	0.252
199	13.003	13.000	12¾	21	Steel	0.003	125	4790	2130	0.225
200	14.033	14.031	14	21	Steel	0.003	150	4785	1845	0.264
201	14.033	14.031	14	21	Steel	0.002	100	3075	1185	0.274
202	14.5035	14.500	13	25½	Cast Iron	0.0035	100	2720	1430	0.235
203	16.004	16.000	14	25½	Cast Iron	0.004	120	2865	1415	0.241
204	20.002	20.000	20	28⅞	Steel	0.002	160	2220	780	0.327
205	20.0025	19.999	20	29	Steel	0.0026	140	2880	1020	0.218
206	20.0025	19.999	20	29	Steel	0.0026	140	2880	1020	0.218

CONTINUOUS MANUFACTURING BY PLACING MACHINES IN ACCORDANCE WITH SEQUENCE OF OPERATIONS

By Oscar C. Bornholt

ABSTRACT OF PAPER

Continuous manufacturing appeals to all manufacturers who have a product requirement large enough to carry out the idea. The paper outlines such an arrangement of machines in use by a manufacturing plant that has been phenomenally successful. Here it is shown not to be necessary to impair the best sequence of operations taking into consideration the gaging points, etc., as would be the case if the operations had to be outlined to accommodate the classification group of machines to prevent the passing to and from the different departments of like machines. An illustration of unit production is given in the manufacture of a universal joint which is familiar to all automobile manufacturers, and also by taking the first few operations on an automobile block cylinder for an example. The two ways of manufacturing are compared, showing in one case the excessive expense of trucking. Cylinders of course are especially adapted to manufacture with machines placed in accordance with sequence of operations, but small forgings can also be produced in quantities much cheaper in this manner as shown in the case of rods. The closing remarks touch upon the raw stock necessary for manufacturing, which is less in the shop where machines are placed in accordance with sequence of operations.

CONTINUOUS MANUFACTURING BY PLACING MACHINES IN ACCORDANCE WITH SEQUENCE OF OPERATIONS

By Oscar C. Bornholt, Detroit, Mich.

Member of the Society

In any manufacturing enterprise the cost of production is very important, and a great deal of money can be wasted if proper facilities are not provided. Even though a plant has the very latest and most efficient machines and fixtures, money can be unnecessarily spent in trucking. Trucking in the machine shop is always looked upon as an unnecessary expense and yet many plants have a large trucking expense. This involves the question whether the manufacturing machines in a machine shop should be laid out in accordance with the sequence of operation, or whether they should be grouped according to the class of operation requiring like machines, such as placing together all milling machines, all drill presses, etc.

2 I will endeavor to show that the arranging of machines according to sequence of operation, as practised by the Ford Motor Company, has a great advantage over the classified machine grouping. In the former case the operations on any part to be manufactured can be outlined according to the best advantage in manufacturing the part. It might be well, on account of the nature of the part to be manufactured, to have a milling operation first, then drilling, then milling, and it would not make any difference what sort of machine followed on each operation. But if the latter arrangement of grouping were decided upon, the operations would have to be arranged so that like operations on the same part would follow each other. For illustration, a milling operation should not come between two drilling operations so that the part would have to be trucked to the drill department first, then to the milling depart-

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

ment, and then back to the drill department. Trucking is expensive and all its labor is non-productive.

3 The trucking item is immense in a large plant when the machines are arranged according to class, as all parts have to be trucked many times before they are finished. When machines are placed according to sequence of operation there is no trucking of parts after the first operation is started, as each operator lays the part down in such a place and manner as to allow the next operator to pick it up and perform his operation, and so on. When finished, the part goes either to the finished stock room or assembling department.

4 A good example of continuous manufacturing is found in the making of tin cans. The body of the can is started at one side of the building in a machine for forming it; it next goes to the body-soldering machine and then to the header which has been fed with the two heads; when the heads are on, the can travels upstairs to have the heads soldered. The first machine sets the pace and the operators of the other machines must keep their machines moving at a similar rate so that the stock will not run short or accumulate. This arrangement therefore helps to increase production.

5 At the Ford plant the machines are arranged very much like the tin-can machines. All parts of a unit assembly are made on machines that are so laid out that the last operations bring them near together. This applies of course only to the large pieces, but all parts of a unit are made in one department under a foreman.

6 Automatic screw machine parts are made in an automatic screw machine department where one man runs several machines. There would be no object or advantage in placing automatic machines among semi-automatic and manual operative machines. It is well understood that there are many operations that require more than one machine, but they are placed to draw from the one machine doing the previous operation. This gives the effect of the whole operation being done on one machine.

7 The operations have to be gone over carefully to ascertain the capacity either by previous records or by good judgment. In many operations more than one machine will be required, but there will not be work enough for two. Although the first cost may seem high it is a great saving to have a machine for every operation and enough of them.

8 The carbonizing and hardening operations are awkward to have in the machine shop, but at the Ford plant a cyaniding and hardening department is placed in the middle of the machine shop.

It is glassed in and thoroughly ventilated with a separate system to carry off the fumes from the cyanide pots. All parts to be cyanided and hardened are led up to this department and thus trucking to a separately located building is avoided. This would amount to several hundred tons of material a day.

9 On account of the great amount of heat generated, the heat-treating and carbonizing departments had to be placed in a separate building where the walls could be opened 60 per cent. Brazing is done in the machine shop, just before the parts reach the assembling department. All shop furnaces are operated with low-pressure air ($1\frac{1}{2}$ lb.) and city gas.

10 As an illustration of unit production, I will take the universal joint which has only four pieces and four rivets. Assuming a production of 80 pieces per hour is required, it would take

80 universal joint knuckles (male)
80 universal joint knuckles (female)
160 universal joint knuckle rings (halves)
320 rivets

11 The universal joint knuckle (male) has six operations, as given in Table 1.

TABLE 1 OPERATIONS ON THE UNIVERSAL JOINT KNUCKLE

Operation	Work	Machines Required	Capacity, per Hour
First	Mill square end	2 Millers	40
Second	Turn to size, $3\frac{1}{8}$ in. diameter	1 Lathe	80
Third	Turn trunnion ends	2 Duplex drills	40
Fourth	Mill ends, shoulder clearances	2 Millers	60
Fifth	File	Bench for filing	..
Sixth	Harden	Furnace in the hardening room in the machine shop; knuckle to be returned to assemble	..

12 The operations on the universal joint knuckle (female) are similar. The rings are broached, and then ground on a disc grinder, which is placed in the machine shop. The grinder is equipped with a dust exhauster and collector so that no emery dust flies to other machines.

13 After all the parts are completed, they are led up to an assembler who also rivets them. They are then inspected and sent to the finished stock room or the assembling department, usually

the latter, since the production of the whole shop must be balanced up.

14 At the Ford plant, the cylinders are trucked from the foundry to the border of the aisle, down which are located the machines which perform the first operation. They are light enough to be carried by the operators to their machines while the latter are mak-

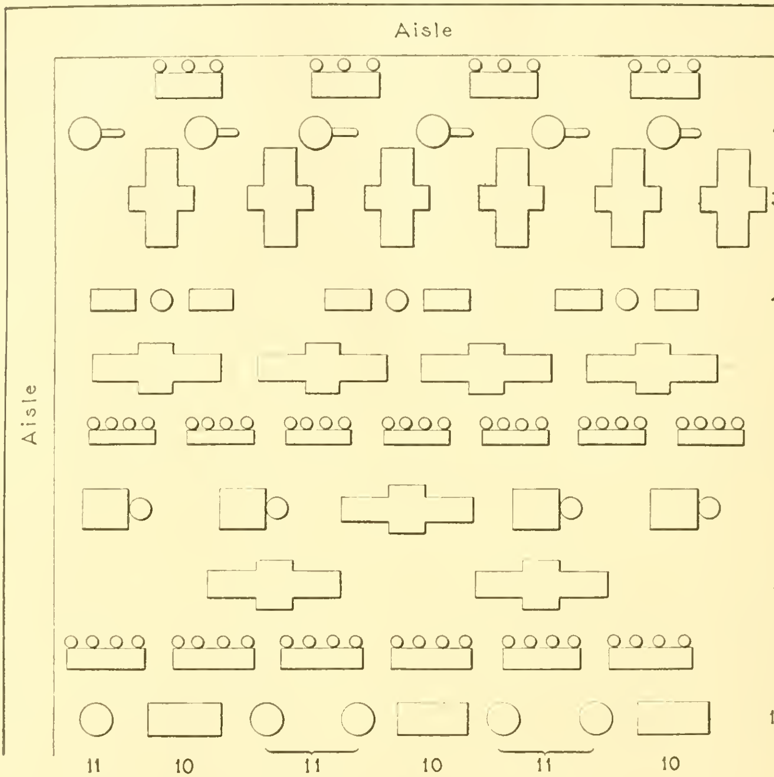


Fig. 1 Sequence Arrangement of Machines in Cylinder Department

ing cuts. The cylinders move to each successive machine until they land in the assembling department which borders the cylinder department. All cast-iron parts are made in the same way; some of the small parts have to be trucked to the assembling department, but in rare cases only. The trucking that is done at the Ford plant is taken care of by many two-ton monorail traveling hoists operated by electricity and forming a small railway system.

15 An illustration of the cylinder department for the first few operations is given in Fig. 1.

First operation—drill, tap and plug three cored holes

Second operation—spot face and inspect. This is one of the most important operations on the cylinder, since it detects any defect that might have occurred in the foundry. It also finishes spots to enable the placing of the cylinder in the jigs quickly and accurately. Many cylinders are thus saved in this jig because it is arranged to adjust the cylinder to ensure its being finished all over.

Third operation—mill bottom

Fourth operation—drill six main bearing bolt holes and ream two of the holes for use in gaging or jigging. The drilling is done in a six-spindle inverted drill press and the two holes are reamed in a single-spindle drill press.

Fifth operation—mill top and sides

Sixth operation—bore cylinder barrel

Seventh operation—water test

Eighth operation—mill ends of cylinder

Ninth operation—finish ream barrel

Tenth operation—drill valve seat holes

Eleventh operation—drill and ream valve-stem holes, etc., until the cylinder reaches the assembling department.

16 It may be of interest to compare the two ways of arranging machines for manufacturing by using the cylinder operations of various kinds: In placing the machines according to operations it is necessary only to truck the cylinder to the first operation and after the last, because it is quite necessary to stock a few cylinders ahead of assembling. If the cylinders were to be machined in departments consisting of like machines, it would be necessary to truck to and from each department. Considering 1000 cylinders a day and the cylinders weighing above 80 lb. each, it would total 80,000 lb. to each department.

17 Grouping the operations on the cylinder to see how many times it is handled in how many departments, there are: drilling, milling, lathe, testing, tapping, babbitting, back to drilling, and grinding. It would be conservative to estimate that the cylinder would have to be trucked about 12 times. On account of some operations it would have to return to a department in which it had already been, and would therefore be handled more times than there are departments.

18 Each handling will amount to 80,000 lb., or 40 tons, and 12 handlings will amount to 480 tons a day, while the total number of feet of movement for each cylinder will be at least 500. This makes 480 tons traveling 500 ft. at the probable rate of 180 ft. a min., which is about the gait of a man trucking. Assuming a man can truck 960 lb., or 12 cylinders, at the above rate of travel, and figuring the necessary time for loading and unloading as 10 minutes, it would

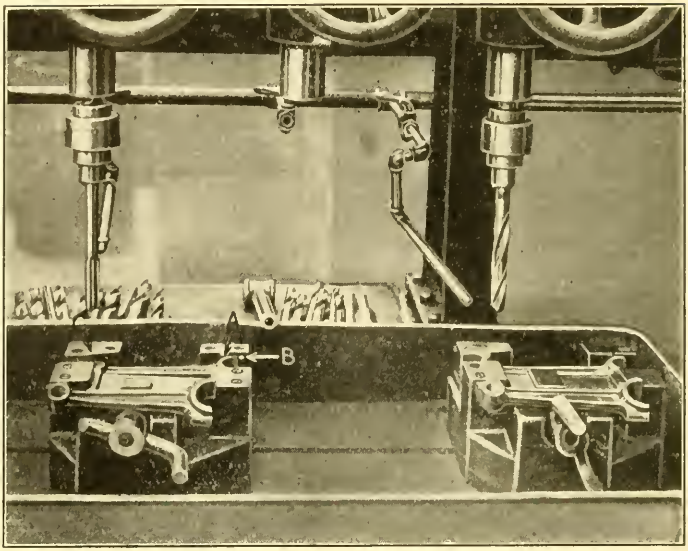


FIG. 2 DRILLING AND REAMING PISTON PIN HOLES

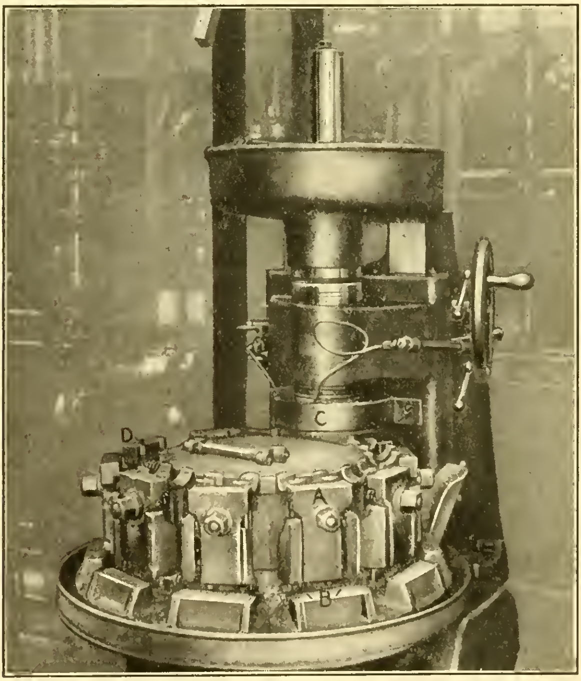


FIG. 3 CONTINUOUS MILLING OF CONNECTING ROD ENDS

require a force of 24 men with trucks to handle the 1000 cylinders per 10 hours.

19 While it may be claimed that the cylinder is especially adaptable to manufacture with machines placed in accordance with the sequence of operations, small forgings can also be produced in quantities much cheaper in the machine shop when the machines are placed in this way.

20 The machining of connecting rods shows how this system is applied where comparatively small forgings are used: These are brought in from the forging shops, and begin their passage down the row of machines which are arranged for the various operations. Nearly all of the machining operations consist of drilling, and the

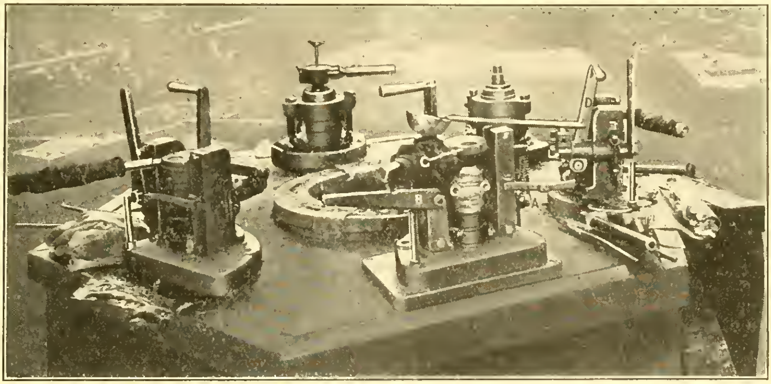


Fig. 4 One of the Babbitting Furnaces for Rods and Bearing Caps

rods pass from one machine to the next, each being fitted to perform a specific operation. A typical view is shown in Fig. 2, where the wrist or piston pin hole is being drilled and reamed.

21 Adjoining this is a continuous milling machine shown in Fig. 3, the correct length being secured by having the piston pin hole slip over a suitable stud at the lower end of the fixture. The rods are held in pairs, as can be seen.

22 As soon as the connecting rods are ready to receive the babbitt, they have reached one of the babbitting furnaces, shown in Fig. 4, which is very near to the last machine. The particular furnace shown happens to be babbitting the caps for the bearings, but is exactly similar in detail to the one which babbitts the connecting rods themselves. After babbitting, the rods are bored; they are then complete and ready to go to the assembling department.

23 There is another advantage in placing the machines in ac-

cordance with the sequence of operations; even though some machines are not worked to their full capacity the amount invested in them is well paid for from the fact that it is not necessary to carry nearly so much stock as when the machines are grouped according to their classification. Each group or department alone would in that case need to have nearly as much raw stock to work with as is necessary with this method to operate the whole series of machines to complete the part.

FOREIGN REVIEW

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

In *The Journal* for May 1913 was printed an abstract of an article by Neumann on Processes in a Gas Producer from the Standpoint of the Second Law of Thermodynamics, in which the author held that there was a loss in heating value of the gas of between 10 and 30 per cent between the time the gas left the fuel bed and the time it reached the exhaust pipe. This statement has met with considerable scepticism both abroad and, judging from letters received at this office, in this country. Attention is therefore called to the abstract of the article of Hudler, in this issue, who holds that the results obtained by Neumann are true only for the very small producer with which the tests were made, and do not apply to producers of the normal commercial sizes. In connection with this the author gives what appears to be a firm foundation for the understanding of the higher efficiency of the large producer as compared with the small one. The difference between center gas and edge gas is also discussed, and the influence of their mutual proportion in the final product on its calorific value forcibly pointed out.

THIS MONTH'S ARTICLES

The Jaeger turbine-driven air pump shows how German designers are proceeding to solve the still unsettled problems connected with the construction of this class of machinery. In the same section are reported the proposed Russian rules for testing fans and compressors, interesting not only in themselves, but also on account of the attractiveness of the Russian market for American built air machinery. The illustrated article on cement machinery, while giving few constructional details, illustrates some of the types of German machinery exhibited at the last Exhibition of Building Trade in Leipzig. In the section Hydraulics is reported another installment of the article of Allievi on the theory of water hammer containing a full discussion of the characteristic of the conduit, and table of its possible numerical values. In the Recovery of Heat Losses in Explosion Engines the questions of how much of the heat of internal combustion may be commercially recovered and methods for accomplishing

it are fully discussed. The Blezinger producer is described in the same section.

As the volumes and speeds of transportation of the materials used in modern engineering increase, their measurement becomes both more difficult and more important. The difficult problem of measuring high-speed air blasts is claimed to be solved by the Morell anemotachometer described in the section Measuring Instruments, where also the Féry Thermo-electric direct-reading calorimetric bomb and a new process for making visible stream lines in liquids are described.

Particular attention is called to the section on Pumps in which the first article discusses the relation between the angle of coupling and ratio of piston areas in coupled double-acting twin-pumps, on one hand, to the dimensions of the flywheel, on the other; the second article contains a mathematical exposition of the theory of centrifugal water pumps, as a basis for a graphical method, to be reported in a future issue of *The Journal.* This permits of a predetermination of the characteristic curves of the pump from its design. Reasoning on the basis of the degree of diffusion, the author constructs a theory of water pumps fully analogous to that of water turbines. In the section Steam Engineering data on the use of Allagit for water purification are reported; natural and mechanical draft in steam plants are compared, the conclusion being that both have their own fields of application, and do not really compete: the blower is an auxiliary to, rather than substitute for, the smokestack. As to the latter, a new type is described, suitable chiefly for places where the stack has to be built very high. The new, grid or dissipator type, is claimed to produce practically smokeless combustion under conditions where an ordinary stack would emit black clouds.

ABSTRACTS OF ARTICLES

Air Machinery

Jaeger Turbine-Air-Pump (*Jaegers Turbinenluftpumpe*, A Förster, *Die Turbine*, vol. 9, no. 23, p. 412, September 5, 1913, 3 pp., 10 figs. *d*). The Jaeger centrifugal air pump belongs to the class of pumps working with an auxiliary liquid; it may be driven either by a high-speed electric motor, or by a steam turbine running at 1500 to 3000 r.p.m. In that case the turbine receives live steam and gives its exhaust steam to the low-pressure stage of the main turbine, so that the pump turbine can be regulated for any speed of rotation, and is entirely independent of electric energy. The air pump, cooling water pump and condenser pump may often be conveniently assembled in one aggregate. The water enters through the admission pipe *a* (Fig. 1A) and after passing through the regulating valve *c*, is thrown by the centrifugal wheel *d* in thin jets into the circular nozzle *e* surrounding the wheel. As shown in Fig. 1B these jets form in the circular nozzle spiral water bands *g*, between which is compressed the air coming in through opening *f*. This air is compressed by being driven forward until it passes into the pressure piping together with the water. The centrifugal wheel is easily accessible; small cross-sections subject to being clogged up are carefully avoided. The bands of water are extremely thin, there being no excessively narrow cross-sections either in the centrifugal wheel or in the circular nozzle, which decreases the amount of water used, and permits the use of comparatively dirty water. By means of the regulating valve *c* (Fig. 1A) the supply of auxiliary water, and thereby the output of the pump may be regulated at will. The graph in Fig. 1C shows the output of a pump of average size, where the weight of air delivered is plotted as a function of either partial pressure or partial vacuum.

Concerning the Draft of the Rules for Testing Fans and Compressors (*Po povodu pravil dla ispytanya ventilatorof i kompressorof*, A. P. Hermann, *Zapiski Imperatorskava Russkava Tekhnicheskava Obshchestva*, vol. 47, nos. 6-7, June-July 1913, p. 161, 10 pp., 11 figs. *p*). A draft of rules for testing fans and compressors prepared by a special committee of the Second Russian Mining, Metallurgical and Machine Construction Convention. These rules are in the main based on the *Regeln* of the *Verein deutscher Ingenieure*. The Russian rules, however, contain also a chapter on Fundamental Elements of the Contract of Tests by which only such guarantees are admittted as can be verified by direct methods, and it is prescribed that for all such guarantees the method of verification must be stated in the contract, as, well as the maximum deviation from the guaranteed figures; while the magnitude of these deviations is left to

the free agreement of the contracting parties, unless it is stated that the actual test values may be below the guaranteed values, no implied assumption to this effect may stand. For turbo-compressors the Russian rules introduce the use of characteristic curves, the respective passage reading as follows: "characteristic curves of compressors are used exclusively in testing turbo-compressors, mainly in testing stations. These curves express the functional relation between the pressure of a gas and the

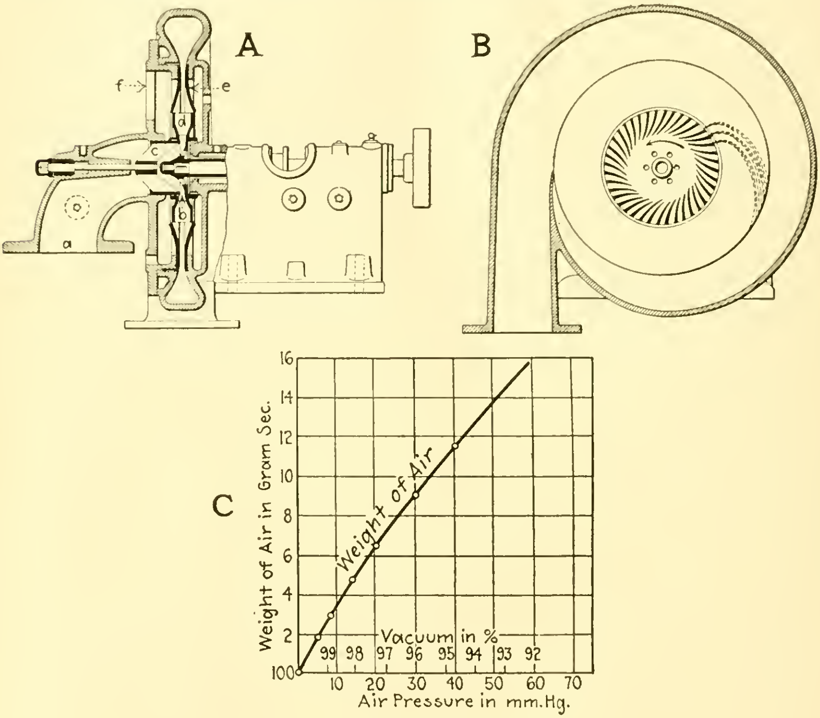


Fig. 1 Jaeger Turbine Air Pump

volume delivered at different speeds of rotation, and are plotted together with the curves of equal isothermal efficiencies. Such curves give a clear picture of the conditions of work of a turbo-compressor where its efficiency varies between the lowest and highest permissible limits, as well as define the conditions of the most efficient work of the compressor."

Cement

Cement Machinery at the International Exhibition of Building Trades in Leipzig in 1913 (*Zementverarbeitungsmaschinen auf der Internationalen Baufach-Ausstellung in Leipzig* 1913, C. Naske, *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 39, p. 1543, September 27, 1913, 2½ pp., 8 figs. *d*). Both hand and power driven machinery has been shown; to the latter belongs the Gaspary artificial stone making machine (Fig. 2 A)

which makes two bricks at a time, and has an output of 9000 bricks in 10 hours; another machine of the same company has an output twice as large. Fig. 2 B shows a sand and gravel washing machine in which counter current washing is combined with trough washing, this making it particularly suitable for handling mixed stuff like sand and gravel. Small hydraulic presses for making floor and wall tiles, as well as the tiles themselves, have been also exhibited. The Steinbrecher cement brick making machine (Fig. 2C) can make one or two bricks at a time. Its powerful lever with high leverage produce, with a mixture of 1 part cement to 3 parts sand, a perfectly water tight brick, which can be used without a protective layer of paint or cement. The parts subject to wear are made replaceable, the profile plate being of hardened steel. Fig. 2D shows the cement pipe stamping machine of the Royal Bavarian Mining Administration. The same concern exhibited the Kunz concrete and mortar mixing machine shown in Fig. 2E and F. This machine, with a capacity of 450 liters (15.75 cu. ft.) has an output of 150 cbm (say 5300 ft.) per day: it is provided with a device for hoisting the mix, which, as well as a winch, are driven by an electromotor forming part of the installation. Several other types of concrete mixing machines have been exhibited and are briefly described in the original article.

Hydraulics

Theory of the Water Hammer (*Théorie du coup de bélier*, L. Alliévi. *Bulletin technique de la Suisse Romande*, vol. 39, nos. 11, 14, 15, pp. 121, 159, 171, June 10, July 25, August 10, 1913. Serial article, not finished. *tA*). Continuation of the abstracts published in *The Journal*, August 1913, p. 1287, and September 1913, p. 1434. The nature of the phenomena accompanying a variable motion of a liquid in a conduit and characterized by continual variations of velocity and pressure is evidently determined by the fact that these variations give rise to continual transformations of the kinetic energy of the liquid column into potential energy (elastic deformations) of the liquid and walls of the conduit, and vice versa. It appears therefore that the laws of these phenomena must be in direct relation with the quantities of energy, either kinetic or potential, contained at every instant in each section of the conduit. Since, however, system [9] (*The Journal*, September 1913, p. 1435), which is the analytical expression of these laws, relates to the data characterizing the conduit only through the intermediary of the characteristic ρ, it is to be expected that this characteristic, which fully defines the permanent operation of the conduit, is also closely related to the quantities of potential or kinetic energy contained in a unit of length of the conduit while the latter is operated under permanent conditions, and it can be shown that ρ can be expressed by half of the square root of the ratio between these two quantities of energy, or that

$$\rho=\frac{1}{2}\sqrt{\frac{W_0}{W}}\ldots\ldots\ldots\ldots[10]$$

where W_0 is the quantity of kinetic energy contained, under normal operating conditions, in a unit of length of the conduit, i.e. the kinetic energy stored up in a unit of length of a column of liquid having velocity

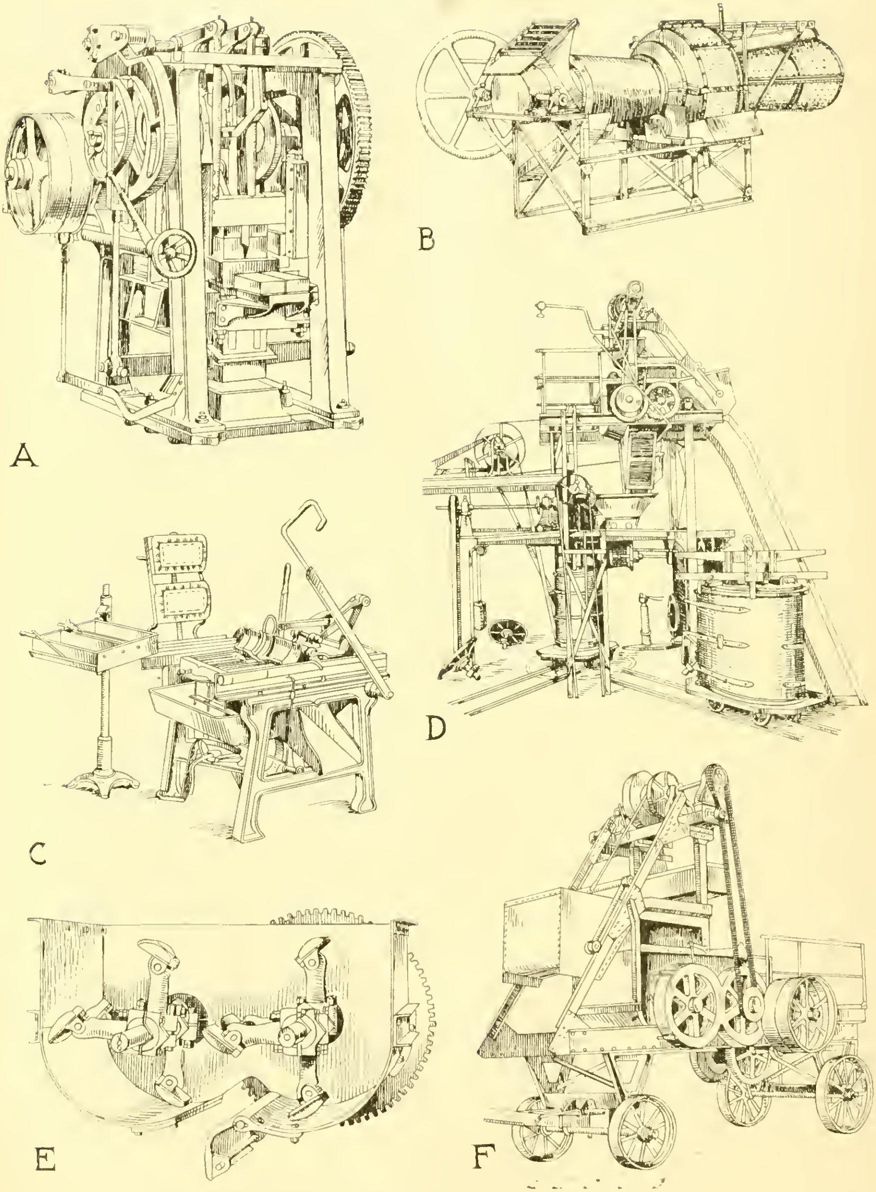


Fig. 2 German Machines Used in the Cement Industry

v_0; and W the quality of potential energy contained, also under normal operating conditions, in a unit of length of the conduit, i.e. the sum of the qualities of energy absorbed, first, by the elastic compression of a unit of length of the liquid column, and, next, by the elastic deformation of the walls of the conduit, within a unit of length of the latter. The next point is to determine the numerical limits between which the characteristic ρ may fluctuate in practical applications.

It has been previously shown (cp. *The Journal*, August 1913, p. 1287) that the velocity of propagation of variations of load along a conduit a varies from 600 to 700 m. for thin-walled pipes of large diameter, to 1200-1300 m. for thick-walled pipes of small diameter, while the normal velocity v_0 varies from 1.50 to 3.00 m./sec. To understand the numerical calculation of ρ, the following must be borne in mind: All the preceding formulae are based on the assumption that the velocity of propagation of variations a, and consequently the ratio $D:e$, are constant along the entire length of the conduit. This assumption is sufficiently exact in certain cases, e.g. with conduits, often very long, for water distribution in cities, but is seldom true in the case of feeds to hydraulic plants, which are of particular interest in this connection. The conduits of this character are inclined, in a vest majority of cases, so that the ratio $D:e$ (where e is the thickness calculated on the basis of the static load to which each section of the conduit is subjected) decreases from top to bottom of the conduit, while a decreases from bottom to top. In such a case an average value of a has to be used, such that, if the variations of pressure were transmitted at this average velocity along the conduit, the time occupied for making the entire length of conduit L would be $L:a$, equal to $\Sigma(l_x:a_x)$, which is the time actually occupied for making at the variable velocity a_x, the sum of the sections l_x forming the conduit of length L. It appears logical to use, in calculating ρ, the average value of a as defined above when a water hammer is considered of sufficient duration to permit the elasticity of the entire conduit to act; this would certainly happen in the case of the so-called counter blow, the duration of which considerably exceeds that of the phase $\mu = 2L:a$ of the direct blow. On the other hand, when direct-blow phenomena are considered, of duration inferior to μ, in the calculation of ρ, for a the value correcponding to the lowest section of the conduit must be taken. In general, however, the extreme limits between which a may vary are close enough to make the use of an average value of a possible in this calculation without materially affecting the exactness of the results.

The following calculation of a conduit having a constant slope is given here as an example of the application of this method. The thickness of the walls is calculated at each point, on the basis of the corresponding static load, for a constant ratio of work R.10^6 kg./m^2, this thickness being subsequently increased by a value, assumed to be proportional to the diameter, say, at the ratio of 0.0025 m. per meter. If therefore the static load in a section of abscissa x be designated by y_x, then

$$\frac{2e}{D} = \frac{1000 y_x}{R\,.\,10^6} + 0.005$$

Taking $R = 7$ kg./mm^2, and introducing the value of $2e:D$ into an equa-

tion of modified form of [1a] (cp. *The Journal*, August, p. 1287) the following expression for the velocity of propagation of variation a_x in the section of the conduit under consideration is obtained

$$a_x = 1425\sqrt{\frac{y_x+35}{y_x+180}} \qquad [11]$$

which is correct to a great degree of approximation. By means of this

TABLE 1 $y_x - a_x$ VALUES

y_x	a_x	y_x	a_x	y_x	a_x
0	628	90	974	350	1216
10	703	100	990	400	1236
20	747	120	1025	500	1266
30	792	140	1054	600	1287
40	834	160	1080	700	1305
50	865	180	1102	800	1318
60	897	200	1122	900	1329
70	924	250	1161	1000	1333
80	948	300	1192	1100	1346

TABLE 2 VALUES OF CHARACTERISTIC ρ FOR DIFFERENT CONDITIONS OF OPERATION

y_0	a	ρ for Velocity		y_0	a	ρ for Velocity	
		$v_0 = 1.50$ m	$v_0 = 3.00$ m			$v_0 = 1.50$ m	$v_0 = 3.00$ m
1000	1184	0.09	0.18	120	861	0.55	1.10
800	1153	0.10	0.21	100	837	0.64	1.28
600	1110	0.14	0.28	80	809	0.77	1.55
500	1082	0.16	0.33	60	777	0.99	1.98
400	1046	0.20	0.40	40	739	1.41	2.83
300	1000	0.25	0.51	30	717	1.83	3.66
200	936	0.36	0.72	20	694	2.65	5.30
140	883	0.48	0.97	10	665	5.09	10.18

formula, Table 1 has been obtained. If the values of this table be substituted in the expression $L:a = \Sigma\ (l_x : a_x)$, average values of a will be obtained for conduits at constant slope for heads between 1000 and 10 meters (3280 to 32.8 ft.). These results are tabulated in Table 2 which contains also the values of the characteristic ρ corresponding to those heads and to the extreme normal velocities $v_0 = 1.50$m/sec. (4.92 ft./sec.) and 3.00 m/sec. (9.84 ft./sec.). This table shows that practically ρ varies between 0.10 and 10. In the next abstract will be shown a simple method of representing these systems of values graphically.

Internal Combustion Engines

ON THE RECOVERY OF HEAT LOST IN EXPLOSION ENGINES (*De l'utilisation des chaleurs perdues des moteurs à explosion*, G. Debesson, *La Technique moderne*, vol. 7, no. 7, p. 209, October 1, 1913. 5 pp., *pt*). The author discusses the question in how far the heat losses of internal-combustion engines admit of industrial recovery. There are certain losses which cannot be so recovered. Thus, in a gas engine even very well constructed, there are losses, about 5 per cent, due to incomplete combustion, while in poorer built engines there may also be losses due to improper regulation of the air admission. In addition, even in the best built engines there are leaks in the valves or past the piston, or due to pre-escape of gases, these losses amounting to, in good engines, about 5 per cent more. Further a certain amount of heat is lost through radiation from the piping and various organs of the engine, and, while some of it may be recovered by proper ventilation of the room, there will inevitably be about 5 per cent more losses from this source, thus making up a total of about 15 per cent of the initial heat value of the gas or liquid used in the engine (working fluid). With producer gas there will be further losses between the gas producer and the engine; the cooling of the gas involves considerable losses which cannot be commercially recovered because the water used for this purpose is not heated high enough to permit of economic recovery of the heat absorbed. Table III gives a summary of the heat losses in various kinds of engines (1 calorie = 3.96 b.t.u., 1 calorie per cu. m. = 0.112 b.t.u. per cu. ft.).

The *recoverable heat units* may be divided into two parts: (*a*) those in the cylinder cooling water, and (*b*) those in the exhaust gases. In small engines with automatic circulation (*a*) is dissipated by radiation from the piping leading to and from the cylinder, but in large engines, where the water is let off into the sewer, the losses are larger, because the water itself always costs something, be it only the labor of pumping it. According to Letombe, the cooling water carries off 700 to 800 calories (2772 to 3168 b.t.u.) per effective h.p-hr. While there are some engines which can do it with 35 liters (9.1 gal.), taken at 15 deg. cent. (59 deg. fahr.) and raised to 35 or 38 deg. cent. (95 to 100.4 deg. fahr.), most engines use a far larger amount of water, the temperature of which varies, of course, within closer limits, the consumption of water rising sometimes as high as 100 liters (26 gal.) per effective h.p-hr. Here an economy may be effected by providing the engine with automatic circulation and the cooling of the water down to the temperature of the surrounding air by means of surface air cooling, thus recovering the heat contained in the cylinder cooling water, and utilizing always the same water for cylinder cooling; with the water at 0.20 francs per cu.m. (say $0.0001 per cu ft.), the loss from the latter source may amount to 0.35 to 1 francs (say $0.07 to $0.19) per hour for an engine of 50 h.p. The recuperator of the heat from the exhaust gases would be placed after the air-cooler of the cooling water, and the limit of the cooling of the gases would be therefore the temperature of the air coming out of the cooler, the initial temperature of the exhaust gases varying from 450 to 600 deg. cent. (842 to 1112 deg. fahr.), in accordance with the change of load on

the engine, the average temperature being around 550 deg. cent. (1022 deg. fahr.). When properly constructed, the heat recuperator from the exhaust gases does not result in the creation of extra back pressure, since the cooling of the gas leads to the reduction of its volume, and the recuperator acts as a condenser of a steam engine.

As to the methods of recovering the heat of internal-combustion engines, the author considers mainly direct heating of air, less known than

TABLE 3 DISTRIBUTION OF HEAT LOSSES, IN CALORIES, IN INTERNAL COMBUSTION ENGINES

Kind of Engine	Per Horse-power-Hour Calories				
	Used	Lost	Losses between Producer and Engine*	Losses at Engine †	Partly Recoverable Losses
City gas engine..........	2260	1624.7	...	339	1285.7
Producer gas engine.....	2779.2	2143.9	386	416.9	1341
Large gas engine, 300 h.p. up.........	2300	1664.7	...	345	1319.7
Large producer gas engine	3000	2364.7	416	450	1498.7
Gasoline engine..........	3675	3039.7	...	551.2	2488.5
Gasoline engine..........	5250	4614.7	...	787.5	3827.2
Heavy oil Diesel engine..	1900	1264.7	...	285	979.7
Heavy oil Diesel engine..	2320	1684.7	...	348	1336.7

* The coal used is assumed to have a heating value of 7520 calories per kg. (13,536 B.t.u. per lb.), while the heat losses under this heading are assumed to be 1000 calories per kg. of coal, or 1800 B.t.u. per lb.

† These losses, as explained in the text of the abstract, are assumed to be equal to 15 per cent of the total heat used.

the system of using special boilers for heating or power purposes. This may be done in the following way: (*a*) by passing air through the engine room so as to collect the heat lost by radiation; (*b*) by passing it then through a battery of heating elements in which circulates the cylinder cooling water; (*c*) finally by passing it through a battery of heating elements through which circulate exhaust gases. The temperature of the air will thus gradually increase until the moment when it comes out of the system which it will do at the point where the exhaust gases come in, i.e., at the hottest part of the system, which is in accordance with the theoretical requirements of a good heating system. This arrangement will of course require the use of a fan, but the power consumed by the latter is insignificant as compared with the saving in heat obtained. The only part of this system which will require special design in construction will be that heated by the exhaust gases, which must have: very good joints, even though the metal will be subject to

serious expansions owing to the difference between the initial temperature of 450 to 600 deg. cent. (842 to 1112 deg. fahr.), and the final temperature which will be as low as can be obtained; it must be easy to clean, and have arrangements for removing the water of condensation formed in part by the combination of excess oxygen and hydrogen, and slightly ammoniacal; must be proof against the action of the gases and liquids contained or formed in the exhaust, mainly of basic nature, but sometimes, especially in engines using liquid fuel, also slightly acid. The author then proceeds to discuss the cases of plants having an engine of 50 h.p. driven by city gas, producer gas, and gasolene, with the recovered heat used in a dryer, and shows that, respectively, the following amounts of water may be evaporated per working day of 10 hours *practically free of charge:* 800 kg. (1763 lb.), 1268 kg. (2793 lb.), and 1035 kg. (2281 lb.).

Injurious Processes in Gas Producers (*Nachteilige Vorgänge in Gaserzeugern*, J. Hudler, *Feuerungstechnik*, vol. 1, no. 24, p. 425, September 15, 1913. 2 pp., *t*). Criticism of a statement of K. Neumann, in the latter's article, The Processes in a Gas Producer from the Standpoint of the Second Law of Thermodynamics, (cp. *The Journal*, May 1913, p. 889), that the gas leaving the fuel bed suffers a loss of 10 to 30 per cent in its heating value before it reaches the exhaust pipe. According to Neumann, this loss is due to the transformation of carbon monoxide into carbon dioxide in accordance with the formula: $2\ CO = CO_2 + C$. The gas used for open-hearth furnaces is obtained from coal, and heated in regenerators up to a temperature of 1000 to 1100 deg. cent. (1832 to 2012 deg. fahr.). The heat losses in this case are, according to Professor Simmersbach (*Stahl und Eisen*, Feb. 6, 1913, p. 239), only about 4 per cent at most, but really even less. In Neumann's test coke was used as a fuel, which practically eliminates the presence of hydrocarbons, and it was to their decomposition that the small losses in the above cited practical cases were due. Further, in practice the temperatures with which the gas leaves the fuel bed (and the gasification of coke without steam is not used practically) are considerably below those prevailing in the regenerator of the open-hearth furnace, while the time of the flow of gases through the former is also shorter than through the latter. If therefore the losses in the producer proved to be several times larger than is usual to find in the regenerator, there must be some other causes for that.

From the analysis of the data of Neumann's experiments referring to the changes occurring in the gas from its leaving the fuel bed to its reaching the exhaust, the author deduces the following facts: (*a*) increase in the contents of water, nitrogen, and, with one exception, carbon dioxide; (*b*) decrease in products of decomposition: carbon monoxide and hydrogen. The theory of decomposition of CO_2 does not explain it. On the other hand, both Neumann and Waldeck have noticed that the gas near the walls of the producer is different from that coming from the center of the fuel bed, the former (Waldeck) being sometimes entirely free from carbon monoxide. The gas in the exhaust pipe is therefore really a mixture of two gases, and that explains the increase in the content of water, nitrogen, and carbon dioxide, and the decrease in carbon monoxide and hydrogen. It

is rather surprising to find that the difference between the gases at the center and those at the edge is such as to affect to a large extent the heat relations. According to the author, this is due to the dimensions of the particular gas producer with which the tests were made which was comparatively small. The amount of gases formed in the edge section, as well as the unfavorable influence of radiation losses, depend on the dimensions of the circumference of the producer, the ratio of which to the area of a section is larger in small producer than in large ones. The author shows by calculation that while in a large gas producer the section composed of the fuel lying near the walls and easily permeable to the gases forms only 1.57 per cent of the total area; in a small producer of the size used for the tests, it forms as much as 10.4 per cent of the total area, owing to which in the latter there is a far larger production of the (low in heating value) edge gas. In addition to that, the gases in the edge section have a far greater velocity than in the center of the fuel bed, which helps further to show that the large losses in the Neumann tests were due to the small size of the producer. *Large producers work more economically than small ones.*

The fact that at full load the heat losses in the gas were smaller than at half load, is explained by Neumann by the assumption that in the former case, owing to the greater velocity of the flow of gas, there is less time left for the decomposition of the carbon dioxide. The present author explains it by the fact that, since, as was shown by Neumann in another investigation, the radiation losses are approximately constant, they form, at full load, a smaller part, in per cent, of the total heat value of the fuel than at part load, and would be double at half load, and treble at a third load. The large losses apply therefore only to small producers, while the large producers are, in the author's opinion, free from that defect, and have reached an efficiency close to the maximum possible limit.

Modern Automobile Constructions (*Neuere Automobil-Konstruktionen*, F. Klinkenberg. *Der Motorwagen*, vol. 16, no. 24, p. 597, August 31, 1913. 6 pp., 7 figs. *d.*). Description of the Windhoff touring car and its engine; the latter does not materially differ from the standard European design for low power engines.

New Gas Producer Constructions with Special Regard to Steam Boiler Firing (*Über neuere Gaserzeugerbauarten unter besonderer Berücksichtigung der Dampfkesselheizung*, Gwosdz. *Zeit. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 37 and 38, pp. 447 and 459. 7 pp., 5 figs. *de*). Discussion of new types of gas producers and their application to steam boiler firing. The *Blezinger* gas producer belongs to the carriage grate type (Fig. 3) and is primarily designed to use low-grade lignite. It works satisfactorily with the German lignites which have a high water content (40 to 65 per cent) and a tendency to large formation of clinker. Its chief advantage lies in the ease with which ash can be removed. The shaft *b* jacketed in its lower part, and reaching down nearly to the grate carriage *a*, is supported on four columns. The upper part of the shaft is brick-lined; the lower part is formed by a cast-iron water-cooled ring *c*, the purpose of which is to prevent the

baking of clinkers on the shaft walls. In the latest types this cooling mantel is designed as a boiler furnishing steam required for the working of the gas producer (this type is shown in Fig. 3). The producer itself is covered by a plate supplied with a peculiar lifting apparatus consisting of a truncated cone *d* provided with two openings *e* and *f* over which are placed two conveyor rolls *g* and *h* uninterruptedly bring-

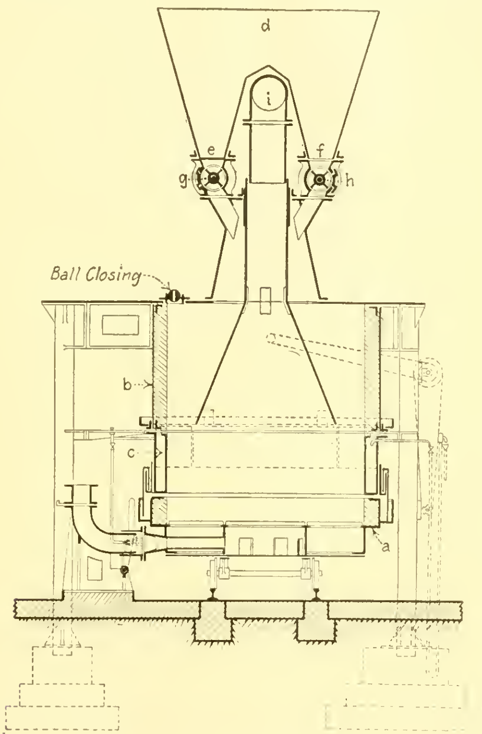


Fig. 3 Blezinger Gas Producer

ing in coal at a uniform rate from the bunkers above. From the upper part of the truncated cone hangs the gas escape pipe *i*, for the escape of gases from the inside of the coal bed, the thickness of the bed being regulated in such a manner that the lower end of the pipe is always in the coal. Between the edge of the shaft and the face of the grate carriage there is a space of 50 mm (say 2 in.) permitting always free motion of the grate carriage; during the running of the producer, this space is packed off by means of a movable sheet of iron dipping into a water seal. Should there be a formation of clinker, a previously cleaned grate carriage is connected with that under the producer, the new carriage having its grate basket filled to the top with fuel in large chunks. When this carriage is shoved in, the clinker layer of the

producer is cut off, without effecting any change in the fuel column. This change of grate carriages takes from 5 to 7 minutes. When fuel with high water content is treated, the gas is led through a water-cooled washer where most of its moisture is removed.

The above described arrangement is goood only if the amount of fine coal in the fuel is not too large. When fuel containing, say, more than 60 per cent fine material, is thrown cold into the producer shaft, the water and tar vapors, in passing through the cold fuel bed thus formed, condense, and in a short time a dough-like mass is formed which does not permit the gas to pass through, so that the action of the producer stops. A special type has therefore been designed (described and illustrated in the original) with a delivery drum in which the fuel is heated up to 75 deg. cent. (167 deg. fahr.) previous to being thrown on the fuel bed. Complete data of tests of double-flue boilers, without either superheaters or economizers, fired by gas from Blezinger gas produce are cited.

An Important Discovery (*Eine wertvolle Entdeckung*, Mk. *Allgemeine Automobil-Zeitung*, vol. 14, no. 38, p. 15, September 20, 1913. 1 p. *g*). The author compares the statement of the Petrol Substitutes Committee of the Royal Automobile Club of Great Britain with that of Mr. Armitage, president of the British Motor Spirit Syndicate, and expresses the belief that the process of the latter is similar to that announced by the Petrol Substitutes Committee, his process consisting in passing a mixture of oil and steam, at a certain temperature, through pipes containing nickel rods. The nickel acts in such a manner that the hydrogen of the steam unites with the oil, and transforms it into a lighter oil making a good motor fuel (Lamplough process).

Measuring Instruments

Concerning the Problem of Controlling the Output of Blowers (*Zur Frage der Leistungskontrolle der Gebläsemachinen*, G. Jakob-Marzella. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 25, p. 392, September 10, 1913. 1 p., 2 figs. *d*). With the modern high speeds of blast (up to 75 m per sec. or 246 ft. per sec.) the usual measuring and registering apparatus cease to give satisfaction. Micromanometers and apparatus of the pitot tube type are unsatisfactory for an extended period of operation and with rapidly varying velocity of blast, the pitot tube being in addition unfavorably affected by eddies in the air passages which cannot be fully eliminated with a strong blast. All these disadvantages are said to have been eliminated in the *anemotachometer* of Wilhelm Morell in Leipzig (Fig. 4), which is like an ordinary anemometer with the difference that the integrating device of the latter is replaced here by a centrifugal pendulum with an indicator pointer. It was feared at first that the inertia of the pendulum and other parts and the friction in the bearings would unfavorably affect the sensitiveness of the indications (tests have shown that with a small blast it takes several seconds for the anemotachometer to pass from its state of rest into full motion), but this inertia lag becomes smaller as the wind increases, and for blasts within the limits of technical application becomes quite negligible; it was proved further by tests that the anemotachometer follows the changes in the blast as closely as a micromanometer with a pilot tube.

The instrument is very easy to read. An anemotachagraph was built and gives satisfaction for the measurement and recording of the velocity of a dirigible airship. The anemotachograph is described and illustrated in the original article.

CH. FÉRY THERMO-ELECTRIC CALORIMETRIC DIRECT READING BOMB (*Bombe calorimétrique thermo-électrique à lecture directe, système Ch. Féry. Le Génie Civil*, vol. 63, no. 21, p. 415, September 20, 1913. 1½ pp., 1 fig. *de*). Description of a new calorimetric bomb. Its distinctive features are: no water is used as the calorimetric mass, the metal of the bomb taking its place, and, second, the rise of temperature produced by the combus-

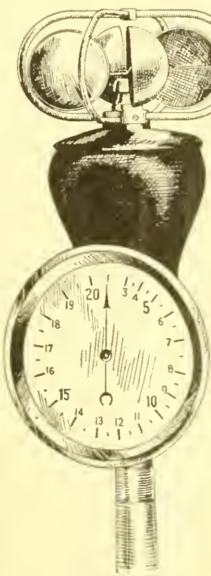


FIG. 4 MORELL ANEMOTACHOMETER

tion of the sample is evaluated by a thermo-electric process. The apparatus is shown in Fig. 5, and consists of the calorimetric bomb proper maintained in the center of a metallic envelop *A* by a disc *E*. The combustible under test is placed in the capsule *J*, and ignited by an electric current sent through a fine wire running between the rods *K* from a small magneto used for that special purpose. *D* is the outside coating; previous tests having shown that thin steel does not insure perfect conductivity of heat, and that this fact leads to lack of uniformity in results, red copper is now used for the coating, 3 to 4 mm (0.118 to 0.157 in.) thick. *C* is the inside nickel coating which can be easily removed in order to weigh the moisture formed. The capsule *J* is always placed at the same height by means of an adjustment shown on the rod supporting it. The current to the wire located between the rods *K* is brought in from the outside contact screws *G*. Oxygen is admitted through

the cock F, and is thrown out in four horizontal jets, so as to avoid the blowing away of combustible if the latter happens to be in the state of powder. The heat produced is read from the millivoltmeter L either in millivolts, or directly in calories, the latter being possible, of course, only when the amount of combustible is equal to the unit weight for the system of heat units used. Tests made with instruments at the Laboratory of Arts and Trades in Paris (the original article contains some data of these tests) have shown the reliability of the instrument.

Concerning a New Method for Making Visible Stream Lines in Liquids (*Über ein neues Verfahren, die Stromlinien in Flüssigkeiten*

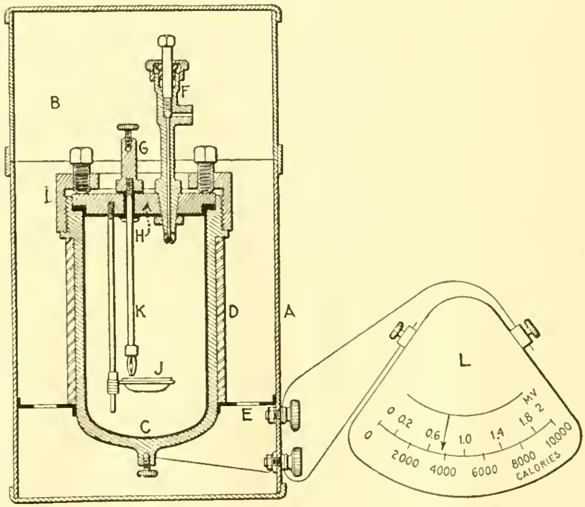


Fig. 5 Fery Thermo-Electric Direct Reading Calorimetric Bomb

Sichtbar zu machen, R. Katzmayr. *Mitteilungen des K.K. technischen Versuchamtes* (Vienna), vol. 2, no. 3, p. 46, 1913. 5 pp., 3 figs. *d*). Discussion of methods for making visible stream lines in solids, liquids and gases. The author recommends the following new method for making visible stream lines in gases. He proposes to hang up a large number of short and very light threads arranged so as to follow one another, without being in mutual organic connection. To eliminate as far as possible the influence of the force of gravity, the flow of the gas may be made vertically downwards. The threads then follow the stream line in the gas flow, which they can do with great precision through being light and short, while the arrangement of a large number of consecutive threads permits the stream lines to be visible even in an eddying flow. The method is exact only for flows having velocities different from zero, and depends on the weight, or rather lightness, of the threads used. Tests have shown that the presence or absence of other threads in front or behind a thread does not affect its indications; there is therefore no screening effect on

one thread due to the presence of another. The method of attaching the threads does not materially affect the correctness of their indications.

Pumps

Concerning the Varying Influence of the Most Suitable Angle of Coupling and Ratio of (Piston) Cross-Sections on the Dimensions of the Flywheel in Coupled Double-Acting Twin Pumps (*Über den wechselnden Einfluss des günstigsten Küpplungswinkels und Querschnittsverhältnisses auf die Schwungradabmessungen bei gekuppelten doppelwirkenden Zwillingspumpen*, Karl Mayer. *Zeits. des Oesterr. Ingenieur- und Architekten-Vereines*, vol. 65, no. 38, p. 630, September 19, 1913. 2 pp., 4 figs. *t*). This article is virtually a continuation of the author's articles in *Die Fördertechnik* (see abstract in *The Journal*, October and November 1912, pp. 1574 and 1891). Only the conclusions to which the author arrives are here reported. The keying on the cranks of coupled double-acting twin pumps to the most suitable angle with respect to the maximum velocity of the suction or pressure water column affects favorably the hydraulic efficiency of the pumps, but has a contrary effect on the dimensions of the flywheel. With the crank drive ratio $\lambda = 1/5$ and the application of the method equality of alternately opposite piston areas (see more below) the weight of the flywheel may be made by 0.4 lighter than when the working cross-sections of the pistons are equal, and the cranks are keyed at an angle of coupling of 90 deg. If $\lambda = 1/3$, the weight of the flywheel is only 0.4 of what it would have been with equal working cross-sections of the pistons and coupling of the pumps under an angle of 90 deg. The method of making the area of the upper side of one of the pistons equal to that of the lower side of another and vice versa, with due regard to the most suitable ratio of cross-sections to the maximum velocity of the suction or pressure water column, affects favorably the dimensions of the flywheel, and the more so, the shorter the connecting rod. When the combined process is used, i.e. when, in addition to the equality of alternately opposite piston areas, the angle of coupling is different from 90 deg., the flywheel dimensions are not as attractive as when the method of equality of alternately opposite piston areas is *alone* used, and, when the equality of maximum velocity in all the four phases (see *The Journal*, October 1912, p. 1574) is preserved, only 0.2 of the flywheel weight is saved. The author therefore arrives at the following general conclusion: with the most suitable angle of coupling, a high hydraulic efficiency of the pumps is attained only at the cost of larger dimensions of the flywheel. When the area of the upper side of one of the pistons is made equal to that of the lower side of another, and vice versa, a saving in the weight of the flywheel is obtained simultaneously with a comparatively high hydraulic efficiency. A further improvement of the hydraulic efficiency by preserving the equality of alternately opposite areas of the pistons, and making the angle of coupling differ from 90 deg., leads to a material decrease in the saving in the weight of the flywheel.

Theoretical and Graphical Study of Centrifugal Pumps (*Étude théorique et graphique des pompes centrifuges*, J. Dejust. *Revue de mécanique*, vol. 33, no. 3,

p. 209, September 30, 1913. 48 pp., 32 figs. *mtA*). By means of a combination of graphical and mathematical methods the author arrives at a process for determining the forms of blades, wheel, collectors and diffusors of centrifugal water pumps, as well as predetermining their characteristic curves. The exposition of this process is preceded by an interesting discussion of the theory of water turbines, omitted here owing to lack of space.

The centrifugal pump supplies the energy to a mass of water so as to lift it to an upper level. If two sections, M and M' (Fig. 6A) be considered, between which energy is supplied to the water, the following equation is obtained

$$\frac{V'^2}{2g}+\frac{p'}{\omega}+z'=\frac{V^2}{2g}+\frac{p}{\omega}+z+T+\eta_i \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where V and V', p and p' are the velocities and pressures in the sections M and M' respectively, z and z' the altitudes of the centers of gravity of the two sections, T the total energy supplied to 1 kg. of water between these two sections, which must be sufficient not only to lift the water to the height H but to overcome all the losses of head due to resistances in the piping and pump. With the following notation T may be expressed as in equation [2]: η_a loss of head in the suction piping and passages at the entrance to the pump; η_i loss of head in the movable part of the pump; η_c losses in the diffusors of collectors of the pump, and the discharge piping.

$$T=H+\eta_a+\eta_i+\eta_e=H_1 \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

The term η_e includes the losses due to the fact that there is an unused head through the water being discharged at a higher head than is absolutely necessary for its operation, as well as through the non-use of the kinetic energy of the water flowing out of the pump. The head H_1 is therefore called *fictitious head*. By substituting in equation [1] for T its value from equation [2] the *general equation of water pumps* is obtained:

$$\frac{V'^2-V^2}{2g}+\frac{p'-p}{\omega}+\eta_i=H_1 \ldots\ldots\ldots\ldots\ldots\ldots [1']$$

which shows, that when the water leaves the pump, energy is stored in it in two forms; one, kinetic, represented by the member $\frac{V'^2-V^2}{2g}$, and the other, potential, by the member $\frac{p'-p}{\omega}$. The velocity of discharge V' decreases therefore when the potential energy increases. In practical applications, however, there is reason for having the water in the conduits flow at a relatively low speed (1 to 2 m., or say, 3.2 to 6.5 ft. per sec.), while at the discharge the velocity rises as high as 40 to 50 m. (131 to 164 ft.). If the speed were suddenly reduced from 40 or 50 to 1 or 2 m., by means of some loss in head, all the corresponding energy would have been lost, which does not happen when the reduction in speed is effected by a gradual increase in section, i. e., by a conversion, or *diffusion* of velocity into pressure. Since the potential energy of the water is only a fraction of the total energy H_1, it can be expressed as a function of the latter

$$\frac{p'-p}{\omega}+\eta_i=\epsilon H_1 \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

where the symbol ϵ is analogous to that expressing the degree of reaction in a turbine, with the difference, however, that it expresses here the *degree of diffusion*, or the opposite phenomenon. It is by the use of this new element of calculation

that the author claims to have succeeded in building up a theory of pumps fully similar to that of turbines.

By substituting ϵH_1 for its equivalent in equation [1′], the following is obtained:

$$\frac{V'^2-V^2}{2g}=H_1(1-\epsilon)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots[\mathrm{II}]$$

This equation shows among other things that when the diffusion is fully taken care of in the movable wheel, the speed at discharge is the same as that at entrance to the pump.

By applying the Bernouilli theorem to the relative motion of the water in the wheel, the following equation is obtained

$$\frac{w'^2-u'^2}{2g}+\frac{p'}{\omega}+z'=\frac{w^2-u^2}{2g}+\frac{p}{\omega}+z+\eta_i\ldots\ldots\ldots\ldots\ldots\ldots[5]$$

where w and w' are the relative velocities, while u and u' the speeds of rotation at the entrance to, and discharge from, the wheel respectively. From this equation is obtained

$$\frac{p'-p}{\omega}+\eta_i=\frac{u'^2-u^2}{2g}-\frac{w'^2-w^2}{2g}=\epsilon H_1\ldots\ldots\ldots\ldots\ldots\ldots[6]$$

which, when substituted into the general equation (1′) gives it the form

$$\frac{V'^2-V^2}{2g}+\frac{u'^2-u^2}{2g}-\frac{w'^2-w^2}{2g}=H_1\ldots\ldots\ldots\ldots\ldots\ldots[\mathrm{I}\ bis]$$

analogous to the equation of velocities for turbines. Further, by making use of the triangle of velocities at the discharge from, and entrance to the pump, the author derives the equation

$$\frac{2V'u'\cos\alpha'-2Vu\cos\alpha}{2g}=H_1\ldots\ldots\ldots\ldots\ldots\ldots[\mathrm{I}\ ter]$$

where α and α' are the angles between the absolute velocities and the velocities of entrainment.

Calculation of a centrifugal pump. For a given range of operation in which the values H_1, V, and η_i are known, there is a system of three equations: [I *bis*] or [I *ter*], [II], and five unknowns: V', u', u, w', w, if equation [I *bis*] is used, and V', u', u, α', α, if equation [I *ter*] is used. Two conditions must therefore be either assumed or determined in some other manner, since otherwise there will be several solutions for each problem, with a definite hydraulic efficiency corresponding to each solution. The hydraulic efficiency of a pump is determined from the following formula:

$$\rho=\frac{gH}{gH_1}=\frac{H}{H+\eta_a+\eta_i+\eta_e}=\frac{1}{1+\frac{\eta_a}{H}+\frac{\eta_i}{H}+\frac{\eta_e}{H}}\ldots\ldots\ldots\ldots\ldots[7]$$

For a definite installation and range of operation $\frac{\eta_a}{H}$ and $\frac{\eta_e}{H}$ are constant whatever pump be used, but $\frac{\eta_i}{H}$ depends on the relative velocity of the water in the pump, section of the wheel and moistened perimeter corresponding to that section: $\eta_i=\frac{X}{\Omega}B_1w^2$, and, since a given output gives for $\frac{X}{\Omega}B_1$ values practically equal for all types of pumps, it may be safely assumed that the loss η_i is proportional to the square of the relative velocity, and, therefore, to attain the maximum

hydraulic efficiency, it is only necessary to select the supplementary conditions and data in such a manner as to have the relative velocity a minimum. These data are: H_1, V, and η_i. Neither H_1 nor V, although the first is indirectly in functional relation with w, materially affect the latter. On the other hand, as shown by equation [6], in order that ϵ give the minimum relative velocity, the supplementary conditions must be selected in a certain manner, since the value of u, and through it those of u', w and w' also depend on these conditions. The minimum of η_i depends, as shown above, on the relative velocity being minimum, but the relative velocity is variable at the entrance and discharge, and, for given degrees of diffusion and velocity of rotation, the relative velocity of entrance varies in the same sense as that of discharge. It is therefore enough to make the relative velocity of discharge minimum.

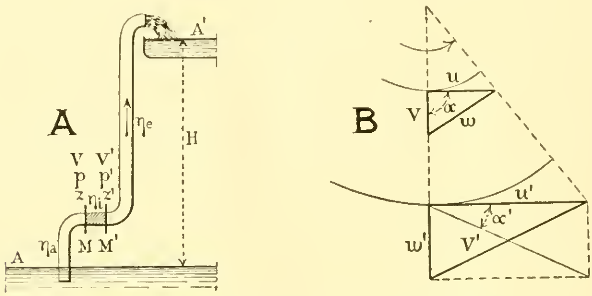


Fig. 6 Centrifugal Water Pumps Diagrams

The author proves further that the minimum of w'^2 corresponds to the *maximum* of the degree of diffusion, a fact which is proved also by tests of pumps designed by other methods. He also proves that the minimum value of w' is determined by the conditions that $V'=u'$, and angle α' be as small as possible, the upper limit of the degree of diffusion being given by the equation

$$\epsilon<\frac{1}{2}+\frac{V^2}{2gH_1} \quad \text{[8]}$$

This process is applied by the author to the calculation of several types of water pumps. As an example the part referring to the old type Farcot pump is here reported. This pump is characterized by radial entrance and discharge (Fig. 6B), i. e., the absolute velocities of entrance and discharge are both directed radially, which fact gives the two supplementary conditions: $\alpha=90$ deg., and $V'^2=u'^2+w'^2$, or $u'=V'\cos\alpha'$. The general equation for angles [I *ter*] becomes therefore: $u'^2=gH_1$, which indicates the tangential velocity to be given to the wheel in order to obtain the head H_1. With u, V and α known, the triangle of velocities at the entrance is determined; to find that at discharge it is necessary to know V' and α'. V' is given by the general equation [II] when the degree of diffusion ϵ is given:

$$\frac{V'^2}{2g}=\frac{V^2}{2g}+H_1(1-\epsilon) \quad \text{[9]}$$

while α' is given by the second initial condition, from which $\cos\alpha=\frac{u'}{V'}$. To make

the solution possible, it is further necessary that $\frac{u'}{V'}<1$ or that $u'^2<V'^2$. That is to say

$$gH_1<V^2+2gH_1(1-\epsilon)\ldots\ldots\ldots\ldots\ldots\ldots\ldots[10]$$

and hence

$$\epsilon<\frac{1}{2}+\frac{V^2}{2gH_1}\ldots\ldots\ldots\ldots\ldots\ldots\ldots[11]$$

which shows that in pumps of this kind the degree of diffusion must be between zero and $\left(\frac{1}{2}+\frac{V^2}{2gH_1}\right)$. To find their efficiency w'^2 must be expressed as a function of the degree of diffusion ϵ which can be done from the expression $w'^2=V'^2-u'^2$, or as

$$w'^2=V^2+gH_1-2gH_1\epsilon$$

which also shows that the minimum of w'^2 corresponds to the maximum of the degree of diffusion.

In the second part of the article which will be reported in a future issue of The Journal, the author shows how to determine graphically the various elements in the design of centrifugal pumps; among other things, the characteristic curves of the pumps designed.

Steam Engineering

Water Purification by Means of Permutit and Allagit (*Die Wasserreinigung mit "Permutit" und "Allagit"*, W. Beck. *Zeits. für Dampfkessel und Maschinenbetreb*, vol. 36, no. 38, p. 463, September 19, 1913. 2 pp., *g*). The most interesting part of the article is that referring to *Allagit*, a substance discovered by Kobelt, in Germany. Allagit is a purified volcanic lava, possessing like the natural zeoliths, the property of easily exchanging bases with the salts contained in water. Allagit is neither a chemical compound nor a zeolith, and its constituent parts are not always present in their stoichiometric ratios. It is applied in the same manner as permutit, and is equally regenerated by a 4 to 5 per cent cooking salt solution.

Natural or Mechanical Draft in Steam Plants (*Natürlicher oder künstlicher Zug bei Dampfanlagen*, Fr. Barth. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 37, p. 1455, September 13, 1913. 8 pp., 8 figs. *cd*). With all its well-known advantages, mechanical draft is more economical than natural draft only under certain conditions: where short working periods or high peak loads of short duration are required, or where it is possible, by forcing the boiler by means of mechanical draft to reduce either the first cost of the plant, or the consumption of coal for starting the boiler or keeping the auxiliary boilers under steam. Mechanical draft in itself does not improve the conditions of firing or efficiency of the boiler plant, and acts favorably on the combustion and output of smoke and soot only where the smokestack is too small. Under certain conditions, however, the trouble may also be removed by a reconstruction of the furnace (increasing the free grate areas), or of the boiler flues (lowering the gas velocity, and providing plenty of room at the points where the gas stream changes its direction), or by raising the stack. It may therefore be expected that in the future as well as at present

natural draft will be the rule, and mechanical draft an exception. With the exception of movable plants (locomotives, locomobiles, ships) mechanical draft is to be used where the conditions of operation are such that the load on the engines cannot be determined in advance, or where the stack draft has become insufficient through the expansion of the boiler plant or introduction of flue gas preheaters, blast heaters, dust collectors, etc. It may also be used to advantage where there are large fluctuations of load, or where cheap coal is burned, offering a large resistance on the grate. It will also be used, of course, where for aesthetic or other reasons a smokestack cannot be built. For steam plants working in

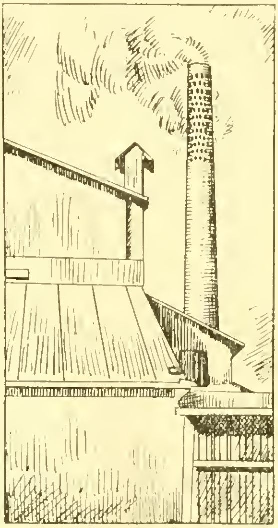


Fig. 7 Dissipator Smokestack

connection with, and as an auxiliary to, water power plants, mechanical draft is to be preferred to natural, on account of its being ever ready to work. The smokestack and blower do not therefore completely exclude one another. In most cases of stationary plants, however, the blower is not so much a substitute for, as an auxiliary to, the stack.

Grid Smokestack (Dissipator Smokestack) and Its Influence on the Smoke Nuisance (*Gitterschornsteine (Dissipatorschornsteine) und ihr Einfluss auf Rauchschäden*, H. Winkelmann. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 37, p. 449, September 12, 1913. 2 pp., 2 figs. *d*). The attempt to obviate the smoke nuisance by the use of exceptionally high smokestacks failed, mainly because the upper layers of the atmosphere proved to be less subject to eddies than the lower strata, and therefore did not produce as rapid a mixing of the smokestack gases with the atmosphere as when a low smokestack was used. An attempt was therefore made to produce the eddy action artificially, and the apparatus described below is the result. It was designed by Professor Wislicenus who has for a number of years been investigating the smoke problem.

The *dissipator* is the upper grid-like section of an otherwise ordinary commercial type smokestack, and has for its purpose to mix the gases coming out from the stack so intimately with the air as to make them harmless. The grid openings (Fig. 7) are formed by stones laid radially and provided with horizontal and conic holes, with a total cross-section five to six times that of the usual upper opening (the cross-section of these grid passages is a function of the upper inner diameter of the stack). The wind enters on one side of the stack through these conical openings, mixes under powerful eddy motion with the smoke and gases in the stack, and produces, already in the stack, a dilution of the latter to nearly one in four; after this the mass of smoke and gases strongly diluted with air is driven out, also violently eddying, through the conical openings on the other side of the stack all along the dissipator. Thus, while from an ordinary stack the smoke and gases come out in a compact mass from a single opening, in the dissipator smokestack they come out in a number of fine wreaths, strongly diluted with air. They rapidly become still more closely mixed with it, to nearly one part in ten, the dilution of the gases growing with the distance from the stack.

When the dissipator smokestack is used, only a haze, but no smoke crown, can be noticed around the top of the stack. With respect to draft, the solid closed portion of the stack must be high enough to take care of that, while the grid section may contribute to its improvement. The cost of the dissipator stack is somewhat greater than that of an ordinary stack on account of the price of the special brick used for the grid section. In the design the main question is to have the grid pass gradually from a few holes to a complete grid on top.

Miscellanea

Pipe Foundry Ardelt (*La fonderie de tuyaux Ardelt. Revue industrielle*, vol. 44, no. 2102/37, p. 505, September 13, 1913. 4 pp., 12 figs. *d*). Detailed description of the foundries for manufacturing cast-iron pipe, one belonging to the Anderten Company in Germany, and another to the General Conduit Company, in Liège, Belgium.

Boiler Inspection Associations in Russia (*Die Dampfkessel-Überwachungsvereine in Russland*, G. von Doepp. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 35, p. 1389, August 30, 1913. 2 pp., 3 tables, *dhs*). Gives a history of the organization of boiler inspection associations in Russia. The associations are to a large extent under government control, the engineers of the associations having the privileges of government service, and the members receiving a 50 per cent rebate in the boiler tax (the tax is on a sliding scale, 4.4 cents per sq. ft. of heating surface up to 200 sq. ft., 3 cents per sq. ft. from 200 to 1000, and 1.5 cents per sq. ft. for all upward of 1000 sq. ft.; owing to the spread of internal-combustion engines it is proposed, however, to modify the tax in such a way as to include the latter also).

The article gives some statistical data as to the boilers used in the country. By age, 34.76 per cent of the boilers belong to the period 1891-1900, and 35.36 per cent have beeen installed after 1900; over 10 per cent are older than 1890, some boilers being older than 1870. The distri-

bution, in per cent, by fuel used is as follows: 3.1 anthracite, 12 wood and wood refuse, 13.8 oil residues, 2 peat, 3.5 gas, 2 mixture of fuel. Of the total of 17,287 boilers registered in the country, there were 1259 battery and single-cylinder boilers, 6992 flue boilers, 1342 multitubular boilers, 1892 locomotive boilers, 2908 water-tube boilers, etc. No data are given as to the number of boilers made in the country and imported, but the number of the latter can hardly be large.

NECROLOGY

EDWIN S. CRAMP

Edwin S. Cramp, until recently vice-president and general manager of the William Cramp & Sons Shipbuilding Company of Philadelphia, Pa., was born in Philadelphia, March 1853. He was the son of Charles H. Cramp and the grandson of William Cramp, founder of the great shipyard that has been known as "the cradle of the navy." He obtained his education in the Philadelphia public schools, graduating from the Central High School in 1871. In the fall of that same year he was apprenticed to the engineering department of the Cramp company and served his four years there, becoming an expert machinist. He then left the machine shop for the drafting department where he spent seven years, familiarizing himself with all details of naval designs. Following this he was placed in charge of the erecting department, erecting all marine engines used by the company, and was subsequently made superintendent of the plant. From this position he rose to general manager of the entire shipyard and in October 1901, on the death of Henry W. Cramp, he became vice-president of the company.

He retired from business a few years ago and moved to New York, where death came on June 20, 1913, as the result of a surgical operation which he underwent about a year ago, leaving him in shattered health. He survived his father by only two weeks. His work side by side with his father for 35 years was effective in making the Cramp company foremost in the production of our "new navy:" his technical and practical training was the cause of exceeding specifications in many trial trips of completed vessels which were run by himself personally and netted the company large sums as bonuses. Mr. Cramp was vice-president of the Society from 1896 to 1898 and was identified with the Pennsylvania Society, American Academy of Social Science, the Geographical Society, Naval Architects and Marine Engineers, and the Engineers Club of Philadelphia.

FRANCIS VALENTINE TOLDERVY LEE

Francis V. T. Lee was born at Winchester, Hampshire, England, August 28, 1870, and attended the grammar school at Manchester, England, and the College Communal at Boulogne, s.m., France. He came to Sherbrooke, Canada, in 1887, and for the greater part of three years was in the service of the Canadian Pacific Railway as secretary to the chief of construction, in charge of the forwarding of material. After resigning from railroad work he spent a year in England and then returned to New York where he remained a year in the employ of the Manhattan Electric Light Company, as assistant under E. E. Stark. Here he came into contact with the late F. A. C. Perrine and formed the acquaintance that so strongly influenced his career.

He left New York to take up the study of electrical engineering at Leland Stanford Junior University, in California, under Dr. Perrine, who was then professor of electrical engineering there. He worked his way by helping Dr. Perrine as secretary and general laboratory assistant. Shortly after being graduated from the university in 1897, he was appointed assistant engineer to John Martin, agent for the Pacific Coast department of the Stanley Electric Manufacturing Company. He rose rapidly in this service, being appointed engineer in January 1898, manager of the office in June 1899 and a year later was made vice-president and general manager of John Martin & Company, electrical engineers and contractors, also district Pacific Coast manager for the Stanley Electric Manufacturing Company, and many other Eastern manufacturers. During this period there came under his direct supervision the erection of many of the earlier lighting and power plants that later were absorbed by the Bay Counties Power Company and the Pacific Electric Railway Company. Early in 1906 he severed his connection with John Martin & Company, but followed Mr. Martin's interests into the Pacific Gas & Electric Company, where he was made assistant to the president; as such he was generally responsible for the construction and operation of the hydro-electric developments of that company. About three years ago he resigned from the service of the Pacific Gas & Electric Company to rest, and his last three years were spent at his old home in England and in traveling on the Continent. He returned a few months ago to Victoria, B.C., where he had intended to make his future residence and died there August 17, 1913. He was a member of the American

Institute of Electrical Engineers, of the American Society of Civil Engineers, of the American Gas Institute, of the American Electrochemical Society, and of the Institution of Electrical Engineers in England.

SAMUEL EDWARD MITCHELL

Samuel Edward Mitchell was a native of England, having been born at Halifax, in June 1875, and received his education at the Halifax Higher Grade School and at the Halifax Technical School. In 1892 he was apprenticed with Fred Hanson & Company, machine tool builders of Halifax, in the works on machines, and two years later went to the Campbell Gas Engine Company, also of Halifax, gas and oil engine builders. He remained two years in the works here and then was promoted to the drafting room, where he remained until 1902, having risen to assistant chief draftsman when he left. In August 1902 he became chief gas engine designer for Tangyes, Ltd., in Birmingham, England, and remained there until April 1905, when he became head of the gas engine department of Ruston, Proctor & Company of Lincoln, England. After two years spent with this company, he came to America and became identified with the Jacobson Engine Company of Chester, Pa., where he remained two years as superintendent, building engines up to 400 h.p. In 1909 he spent nearly a year as gas engine designer with the Minneapolis Steel & Machinery Company, of Minneapolis, Minn., on their large double-acting gas engines. From July 1910 until his death he was general superintendent of the Geo. D. Pohl Manufacturing Company, of Vernon, N. Y., builders of gas and gasolene engines; he had just completed designs of a new line of gas engines for this company and was engaged in some important developments in oil engines at the time of his death, August 19, 1913.

THURSTON MASON PHETTEPLACE

Thurston Mason Phetteplace was born at Providence, R. I., on May 3, 1877, and received his education there, in the English and Classical High Schools, and in Brown University, where he was graduated in 1901 in mechanical engineering. After leaving school he was employed at the Builders Iron Foundry and as instructor in drawing at Brown University, later becoming instructor in mechanical engineering there. In 1909, he received

a degree of Master of Arts from Columbia University, and was appointed associate professor of mechanical engineering at Brown University. At the time of his death on September 7, 1913, he was engaged, in addition to his professorship, in consulting work in the firm of Kenerson, Brooks & Phetteplace, his specialty being automobile construction and gas engine design. He was president of the Providence Association of Mechanical Engineers, and held membership in the Society for Promotion of Engineering Education.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

American Institute of Consulting Engineers. Status and professional relations of the engineer. *New York, 1912.* Gift of institute.

American Institute of Metals. Trans., vol. 6. *Buffalo, 1913.* Gift of institute.

Association of Railway Telegraph Superintendents. Proc. annual meeting, St. Louis, Mo., 1913. *Milwaukee, 1913.* Gift of association.

Bautechnische Gesteinsuntersuchungen, J. Hirschwald. Vol. 2, pts. 1–2; vol. 3, pt. 1. *Berlin, 1912.*

Brazil. Ministerio da Viaçao e Obras Publicas. Boletin Terceiro Anno. Nr. 7, tomo VI. *Rio de Janeiro, 1912.* Gift of Brazil. Ministerio da Viaçao e Obras Publicas.

East Orange (N. J.) Board of Water Commissioners. Fourth annual report, 1912. *East Orange, 1912.* Gift of board.

Die Entstehung des Dieselmotors, Rudolf Diesel. *Berlin, J. Springer, 1913.* Gift of author.

A presentation copy "To The American Society of Mechanical Engineers, in remembrance of the kind reception given me in New York in 1912, and of your trip to Germany and especially to Munich in 1913." It gives the results of tests of the engine which the author invented. It is especially interesting to note the experiments with coal dust fuel.

Les Foyers de Chaudières, Andre Turin. *Paris, 1913.*

Die Gesetze des Wasser-und Luftwiderstandes und ihre Anwending in der Flugtechnik, Oscar Martienssen. *Berlin, 1913.*

Handbook for Heating and Ventilating Engineers, J. D. Hoffman assisted by B. F. Raber. *New York, McGraw-Hill Book Co., 1913.*

Handbuch für Eisenbetonbau. Ed. 2, vol. 12. *Berlin, 1913.*

Hydraulic Turbines with a Chapter on Centrifugal Pumps, R. L. Daugherty. *New York, McGraw-Hill Book Co., 1913.*

The enormous recent growth of hydro-electric projects has given emphasis to the design and construction of water wheels. There are chapters on the selection of a turbine, and on installation costs and power costs.

Mechanics and Heat, an elementary course of applied physics, J. Duncan. *London, Macmillan & Co., 1913.*

An elementary textbook for students who are to take English civil service examinations.

Les Moteurs Thermiques dans leurs rapports avec la thermodynamique, F. Moritz. *Paris, 1913.*

New Jersey Board of Public Utility Commissioners. Second annual report. 1912. *Union Hill, 1913.* Gift of board.

——Abstracts of Reports, 1912. *Trenton, 1912.* Gift of board.

New Orleans. Sewerage and Water Board. Twenty-sixth semi-annual report. *New Orleans, 1912.* Gift of board.

Pittsburgh. Department of Public Works. Annual Report Bureau of Water 1912. *1912.* Gift of Bureau of Water.

Polytechnic Engineer. Vol. 13, 1913. *Brooklyn, 1913.* Gift of Polytechnic Institute of Brooklyn.

Principles of Industrial Organization, D. S. Kimball. *New York, McGraw-Hill Book Co., 1913.*

The work treats of the whole field of organization of factories, covering planning, cost keeping, depreciation, wages, purchase of materials and location of plant. A distinct contribution to the literature of management.

Railway Library 1912, compiled and edited by Slason Thompson. *Chicago, 1913.* Gift of Slason Thompson.

Sociéte suisse des Ingenieurs et Architectes. Compte Rendu du Comité Central pour la période fin Juillet 1911 à fin Juillet 1913. *Zurich, 1913.* Gift of society.

Society for the Promotion of Engineering Education. Proc. 20th annual meeting. Vol. 20, pt. 2. *Ithaca, 1913.* Gift of society.

Some Tendencies and Problems of the Present Day and the Relation of the Engineer thereto, G. F. Swain. (American Society of Civil Engineers, Annual Convention, June 18, 1913). Gift of author.

Steam. Its Generation and Use. ed. 35. *New York, 1913.* Gift of Babcock & Wilcox Co.

Technische Untersuchungsmethoden zur Betriebskontrolle, Julius Brand. ed. 3. *Berlin, 1913.*

Technical Gas and Fuel Analysis, Alfred H. White. *New York, McGraw-Hill Book Co., 1913.*

The author has based his work on the various committee and official reports. The increased demand for economy in the use of fuel has necessitated increased accuracy in testing fuels and the products of combustion.

Work of Edward A. Moseley in the Service of Humanity, James Morgan. *New York, Macmillan Co., 1913.*

Mr. Moseley was for 20 years secretary of the Interstate Commerce Commission, and was a pioneer in advocating the introduction of safety appliances on railroads.

Gift of Wm. Paul Gerhard

Esselborn, Karl. Lehrbuch des Tiefbaues. *Leipzig, 1904.*

Kurz, August. Taschenbuch der Festigkeitslehre. *Berlin, 1877.*

Ligowski, W. Taschenbuch der Mathematik. ed. 2. *Berlin, 1873.*

———Taschenbuch der Mechanik (Phoronomie, Statik und Dynamik). *Berlin, 1868.*

Neumann, Paul. Luftschiffe. *Bielefeld-Leipzig.*

Gift of 3d International Congress of Refrigeration

Deutscher Kälte-Verein. Bilder aus der Deutschen Kälten-industrie.

THE FRIGATOR SYSTEM, J. Gust. Richert. Translated article from *Revue générale du Froid. Stockholm, 1913.*

AN INVESTIGATION OF THE SECOND LAW OF THERMODYNAMICS, J. T. Wainwright. *Chicago, 1913.*

NEW THERMODYNAMICS, J. T. Wainwright. *Chicago, 1913.*

NOTES ON THE WORK OF THE SECTION FOR PHYSICS, CHEMISTRY AND THERMOMETRY OF THE FIRST INTERNATIONAL COMMISSION OF THE ASSOCIATION INTERNATIONALE DU FROID, H. K. Onnes. *Leiden (Holland), 1913.*

UNITED ENGINEERING SOCIETY

DINNER GIVEN TO CASS GILBERT, ARCHITECT, April 24, 1913, F. W. Woolworth. *New York, 1913.* Gift of author.

DUTIES OF THE BUREAU YARDS AND DOCKS (reprint from Confidential Bulletin no. 13, Public Works of the Navy), June 1913. *Washington, 1913.* Gift of Alfred Noble.

FIRE TESTS OF FLOORS IN THE UNITED STATES, I. H. Woolson. (International Association for Testing Materials, 6th Congress, New York). *New York, 1912.* Gift of author.

OM HÄSTSKOSÖMMET OCH DESS TILLVERKNING SAMT NAGRA DRAG UR HOFBESLAGETS HISTORIA, K. J. Sunström. *1911.* Gift of F. B. Gilbreth.

The author desires very much to have samples of every kind of horseshoe nail that there is, in order that his next book on this subject may include American as well as European. K. J. Sunström, Orebro, Sweden.

INTERNATIONALEN KÄLTEKONGRESS (DRITTEN) FESTSCHRIFT, Washington–Chicago, September 15-24, 1913. *Berlin, 1913.* Gift of congress.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION. Forms for special assessments, Illinois. *1913.*

———Work Scenes. Vitrified Brick Roadway. Gift of association.

OHIO. PUBLIC SERVICE COMMISSION. Report, 1912. *Springfield, 1913.*

———A compilation of the laws of Ohio affecting the Regulation of Railroads and Public Utilities, 1913. *Columbus, 1913.*

———An act to create the public utilities commission of Ohio to prescribe its organization, etc. *1913.* Gift of commission.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION. Proc. 20th annual meeting. Vol. 20, pt. 2. *Ithaca, N. Y., H. H. Norris, 1913.* Gift of society.

An especially interesting series of papers on engineering laboratories. Professor Magruder of Ohio State University made a visit to about twenty-five American mechanical laboratories, and summarizes his discoveries.

THIRTY YEARS OF NEW YORK, 1882–1912, being a history of electrical development in Manhattan and the Bronx. *New York, Press of New York Edison Company, 1913.* Gift of New York Edison Company.

This is an extremely interesting volume, giving not only a history of the company, showing its marvellous growth, but containing much matter relating to old-time New York, the New York of the horse car, the gas-light, and the elevatorless building; a city without electric cars or telephone. The work is profusely illustrated, having many reproductions of sketches by Joseph Pennell, Vernon Howe Bailey and others.

EXCHANGES

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS. Trans. vol. 7. *New York, 1911.*

Brooklyn Engineers Club. Proc. 1912. *Brooklyn, 1912.*

Ecole d'Application du Genie Maritime. Cours de Construction du Navire. Vol. 3. 1910–1912.

TRADE CATALOGUES

Asbestos Protected Metal Co., *Beaver Falls, N. Y.* Bull. 53, asbestos for roofs and walls.

Beseler, Chas. Co., *New York.* The stereomotorgraph model C.

Under-Feed Stoker Co. of America, *Chicago, Ill.* Publicity magazine, August 1913.

Wagner Electric Manufacturing Co., *St. Louis, Mo.* Bull. no. 101, single-phase motors, September 1913; no. 102, poly-phase motors, October 1913.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

925 General manufacturing man thoroughly experienced in gas engine work and the handling of men. An excellent opportunity. State age, compensation desired, full experience and reference. Apply through the Society.

926 Machine and tool expert, thoroughly experienced and capable of taking charge of planning and rate setting department in a large gas engine shop; must have good habits and self control. State age, compensation, full experience and references. Apply through the Society.

928 Competent man with mechanical designing ability, to act as chief engineer and general superintendent of plant manufacturing large and heavy machinery. Location, Michigan.

930 Railroad engineer, experienced in selling goods, acquainted with railroad officials, preferably not over 35 years of age.

1001 Works engineer, preferably man with technical education, familiar with overhead cranes, open-hearth furnaces, tracks and all machinery and buildings required in a steel foundry, to have charge of plant engineering department and construction work outside of that handled by the master mechanic. Excellent opportunities for a man who can satisfactorily fill this position. Salary not to exceed $175 per month. Location, Illinois. Apply through the Society.

1003 Mechanical engineer with experience in production engineering, or in the Taylor system of scientific management, or one having a liking for this kind of work; Cleveland concern.

1004 Two vacancies in section of wood preservation Forest Products Laboratory. Men wanted with ideas and originality; large experience is not essential; must be graduates of technical institutions. Examination will probably be held within the next three to six months and will have to be passed by those securing the positions. Howard F. Wein, United States Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wis.

1005 Thoroughly practical, hustling shop foreman, experienced in engine and pump work; a thorough mechanic, able to produce the maximum output of highest quality at lowest cost, and familiar with best and latest

up-to-date practice. State age, experience, references, and compensation expected. Apply through the Society. Location, Massachusetts.

1006 Assistant shop manager, good judge of workmen, accustomed to careful and accurate manufacturing; $1500 a year. Location, Pennsylvania.

1007 Man educated in one of the first-class technical schools, preferably with degree of mechanical engineering and who has done practical work with marked success in machine designing; good administrator, of large vision and proven ability whose record is convincing beyond any question; man who commands respect with people in a business way and who can win the enthusiasm of those working under him; technical knowledge as an engineer should be both deep and broad in all things having to do with the origin and development of machinery. Apply through the Society in written application to No. 1007.

1008 Efficiency engineer, for a time under instruction, in plant of 700 workers. Position permanent and good opening for a bright young man of three or four years experience in practical work and with the desire and the training that will make success in this work. Salary $150 per month.

1011 A young man with technical training, who has had two or three years experience in the construction or operation of gas plants or gas plant machinery, wanted by a manufacturing firm in Midddle West for installation work in this country on a new high-grade apparatus used in the gas industry. Good opportunity for the right man. Apply through the Society.

1012 Plant manager with executive ability and tact, to be jointly responsible with superintendent, for physical equipment and high grade efficiency of two plants in New York State. Prefer man at beginning of career rather than with established position at advanced salary. Apply through Society.

1013 Gas engineer familiar with electrical work, would prefer a young man member of the Society, with a few years practical experience.

1014 Assistant superintendent with qualification to develop into Superintendent. Experienced on moderately heavy work, as machine tool building, with good knowledge and experience in tools, jigs, and fixtures, heat treatment for tool steel and cutting feeds and speeds for working both cast-iron and cast steel. Some knowledge of electrical work beneficial but not necessary, must be capable of adjustment to piece-work shop. Apply through Society. Location New Jersey.

1021 Efficiency engineer familiar with technology of steel industry. Must be competent to carry entire proposition. Apply through Society.

MEN AVAILABLE

300 Member, age 36, ten years designing and building steam, electric and gasolene hoists for contractors, railroad and mine work. Good manager and systematizer, accustomed to handling men; wants similar position requiring executive ability preferably in the West. At present employed. Can furnish first-class references.

301 Member, technical graduate, 31 years of age, desires to locate with company of consulting engineers or corporation as works manager, me-

chanical superintendent and efficiency expert, wide experience in central station work, designing, purchasing equipment, superintending installations, construction and operating departments; accustomed to consulting work in the investigation of power production in relation to isolated plants for large corporations. Also experienced in mill and reinforced concrete construction work.

302 Member, age 36, at present employed, desires change. Experienced in the design of engines and boilers, steam power plants, structural steel and general engineering; has executive ability. Position must offer fair salary to start and advancement.

303 Member, age 33, technical graduate now employed, desires change. Ten years experience in mill engineering and central station work consisting of designing, specifications, buying equipment, supervision of installation, management of operation and maintenance. Accustomed to handling high-grade men. Would like position as plant engineer or with consulting engineers. Excellent references.

304 Member, 37 years of age, 17 years practical manufacturing experience as workman, draftsman, foreman and superintendent with concerns manufacturing steam appliances, automatic machinery, sheet metal, brass rod and wire goods. Short experience in Great Britain supervising manufacture of machinery. Considerable experience in factory organization work. Desires position as factory executive.

305 Sales manager has handled successfully well-known accounts, practical, systematic, good correspondent and estimator. Will accept the responsibility necessary for the entire management of the office, or will handle the account for New York and the East. Broad acquaintance in the engineering, contracting and manufacturing field. Competent to establish foreign products in the United States.

306 Junior member, age 32, desires immediate connection. Twelve years experience, five years gas engine drafting, detailing, designing, checking; three years special machinery, designing, overseeing; two years refrigerating machinery; one year costs, systematizer, time-study; shop foreman, assistant master mechanic. Prefers New York district; alert, capable, efficient, quiet. Salary $1800.

307 Graduate mechanical engineer, Junior member, two years teaching mechanical engineering subjects, two years designing and drafting on mechanical and structural work. At present instructor in machine design. Desires position as chief engineer or works engineer for shop in Middle West.

308 Member, age 42, desires position as assistant manager or general superintendent; practical mechanic, 23 years experience in office, stores and shop in the manufacture of internal-combustion engines, stationary and tractor, marine engines, steam and power pumps, mining machinery steam and locomotive work, electric motors, transformers and starting devices. Design and erection shop and foundry buildings, steam, electric, pneumatic and hydraulic power plants. Competent to assume full charge.

309 Sales engineer desires position where a knowledge of machinery and mill supply trade in United States and Canada is essential; seven years varied engineering experience, nine years in selling end. Experience in correspondence and design of selling contracts.

310 Graduate M. E., age 27, married; three years experience with large construction firm, three years experience in mechanical and engineering departments of large industrial plant. Desires to locate in East. At present employed.

311 Technical graduate desires position requiring engineering, executive or confidential ability, or to become associated with a firm of consulting purchasing or inspecting engineers; practical manufacturing experience in iron and steel castings and machinery; can thoroughly satisfy anyone looking for a man of exceptional experience and ability.

312 Factory manager, member, technical graduate, thoroughly familiar with both the Taylor and Emerson systems of scientific management, possessing considerable executive ability, initiative, self reliance and tact in the handling of men, desires position where increased production at a decreased cost is the prime object. Best references; at present employed.

313 Junior, age 25, graduate mechanical engineer, five years experience in design and manufacture of marine and stationary gasolene and oil engines. At present employed; will consider any proposition having opportunity for advancement.

314 Member; now employed, with 17 years experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, graduate Massachusetts Institute of Technology in mechanical engineering, post graduate course in electrical engineering, desires permanent position in New York City, salary to start $4000.

315 Member desires position as works manager, superintendent or mechanical engineer; competent to organize all departments of manufacturing plant along modern lines, long experience, best reference.

316 Executive engineer, $8000 diplomatic progressive business man. Education technical and legal; wide experience in designing and operating large metallurgical, chemical and manufacturing plants, consulting and purchasing, unsurpassed references.

317 Student member desires part time work, New York or New Jersey.

318 Graduate mechanical engineer, four years experience in woodenware and wood-working business, desires position as superintendent large manufacturing concern or production engineer where exprience in handling labor and designing special machinery is required. At present employed, married, salary $200. Location, Middle West preferred.

319 Junior member, age 28, technical graduate, aggressive and energetic, has tact and proven business ability, experienced in shop, design and efficiency engineering, desires position connected with efficiency and scientific management work.

320 Member, age 35, technical training, wishes to become engineering assistant to executive of strong, growing concern, with view to taking independent responsibility; 12 years commercial experience in responsible engineering capacities; three years in charge engineering work at leading technical school. Character of work and opportunities for advancement more important than immediate compensation.

321 Member, technical graduate, age 42; over 20 years experience in manufacture of gas engines, steam, electric, and gasolene locomotives; wide experience in pattern, foundry, boiler and sheet-iron work. Familiar

with modern shop equipment, methods and management, piece work, premium plans, efficiency methods, inspection systems, etc.

322 Junior member, age 30, experienced in design, construction and superintendence of high and low-tension substations, transmission lines, etc., desires connection with large contracting firm or manufacturing plant requiring services of graduate mechanical and electrical engineer. Best references, moderate salary.

323 Junior member, age 27, technical graduate; employed by firm doing miscellaneous plate business; experienced in detailing and estimating, desires position in estimating department of company doing similar work or with contracting company.

324 Middle-aged man with technical education; experienced in manufacturing problems, design, construction of special machinery and tools for more efficient production. Could offer line of punching and stamping presses with distinctive features.

325 Member, 15 years engineering experience, desires position as purchasing agent; 6 years experience specifying, buying and inspecting. Present salary $2400.

326 Member, master's degree from Cornell, desires position as electrical, mechanical or efficiency engineer, purchasing agent or manager of an industrial plant. Has had 20 years experience, designing, constructing, operating and managing. Can give best of references.

327 Junior member, age 25, graduate mechanical engineer, 1911, broad experience as factory inspector; desires position with chance for advancement. At present employed.

328 Member since 1889, 47 years of age, experience at bench and as superintendent in shops making special tools and interchangeable machinery; designing engineer in large chemical works; engineer of construction and of tests in central heating plant; university professor in mathematics and mechanical engineering; director of technical schools.

329 Member, 35 years of age, graduate of Cornell University; wide experience in design, construction and operation of power plants and other machinery; design and superintendence of mill-building construction; desires position with large corporation as supervising engineer to take complete charge of all power operation, repairs and new construction work. At present employed and will consider only high-grade position.

MEETINGS

NEW YORK MEETING, OCTOBER 14

Unusual interest was aroused at the first meeting in New York, through the introduction of the subject of Aviation as the topic for the evening. The paper was by A. A. Merrill, lecturer on Aeronautics at the Massachusetts Institute of Technology. Mr. Merrill discussed the subject of stability, and by the aid of the blackboard made a clear presentation of the elementary principles upon which stability is based. The present types of aeroplanes are decidedly unstable and the speaker contended that the subject is an engineering one which should receive greater attention on the part of trained engineers, and that more substantial progress would be realized if laboratory methods were introduced in this country, such as have been so successful in the development of flying machines in France.

The general discussion, for the most part, took the form of questions asked by the audience and answered by the speaker of the evening. Later, however, those in attendance were entertained by E. A. Sperry, and his son, L. B. Sperry, who showed lantern slides and gave a most interesting account of the practical work which they have accomplished through the use of a gyroscope in connection with Curtiss machines. Mr. E. A. Sperry held that it was not desirable to attain the degree of stability advocated by Mr. Merrill. He instanced the case of the giant ocean liners with a metacentric height of only fifteen inches—almost devoid of inherent stability. Such a construction leads to smooth riding over the rough seas, and in like manner an areoplane without inherent stability will ride more smoothly than one which through a constant change of base of the machine tosses with every change in air current in order to maintain its stability. Mr. Sperry has worked along the lines of using the gyroscope which gives a constant base line in connection with a machine which lacks the stability advocated by Mr. Merrill.

There was a written discussion by W. Wallace Core, and in his closure Mr. Merrill said that he believed an apparatus such as Mr. Sperry used would be safer and the plan would be better if the gyroscope were applied to a stable machine than to those of the present type.

WORCESTER MEETING, OCTOBER 17

In accordance with the new plan of the Boston committee, the first of the group meetings in the vicinity of that city was held in Worcester on October 17, with a total attendance of 222. A local committee, consisting of Wm. W. Bird, chairman, C. A. Read, C. M. Allen, V. E. Edwards and S. R. Riley, coöperated with the Boston committee in the very complete arrangements.

Over 100 of the Boston membership were in attendance, and the large party going by the noon train from Boston was met upon arrival with automobiles and conducted to the electrical building of the Worcester Polytechnic Institute, where luncheon was served. The party was then organized into ten different groups for the purpose of visiting the different industrial plants of Worcester. These trips included the Worcester Electric Light Company, Webster Street plant, the Reed and Prince Manufacturing Company, the American Steel and Wire Company, Quinsigamond works, Graton and Knight Manufacturing Company, the Crompton and Knowles Loom Works, the United States Envelope Company, Logan, Swift and Brigham plant, the Osgood Bradley Car Company, the Worcester Pressed Steel Company, the Heald Machine Company and the Norton Company Works.

Those who did not desire to participate in these trips were invited to attend a lecture at the institute on Aeroplane Propellers Experiments, by Prof. David L. Gallup, which took up somewhat in detail the data obtained at the institute testing plant during the two years of its operation. A demonstration in the hydraulic laboratories followed the lecture.

The entire party reassembled at four o'clock at the works of the Norton Company, where three short talks were given. The first, by Aldus C. Higgins, was confined to abrasives and was illustrated by lantern slides. Artificial abrasives, by aid of the electric furnace, are the only ones used by the company, and Mr. Higgins traced their manufacture from raw material to the crushed lumps, in which condition the abrasives are sent to the grinding wheel plant. At this point, the second speaker, Carl F. Dietz, told how modern grinding wheels are made, showing the important operations, and following a wheel from department to department by means of lantern slides. Mr. Dietz closed his talk with slides which showed the efficiency of the different abrasives on various materials and also how these efficiencies are determined.

Charles H. Norton next spoke on the use of grinding wheels, emphasizing that the modern grinding machine is a manufacturing tool by means of which it is possible to produce work rapidly of great accuracy. He had grinding samples on exhibition which showed that for low production cost the lathe must be used only as a roughing tool, leaving all the finishing to the grinding machine. An inspection of the Norton works then followed.

Dinner was served at seven o'clock in the New Bancroft Hotel, at which the senior Vice-President of the Society, Prof. Ira H. Hollis, presided, and two interesting addresses were made.

Mr. James Logan, a former mayor of Worcester, was the first speaker, and called attention to various points connected with the origin and growth of the several Worcester industries, pointing out that practically all of them had started from very modest beginnings and had grown by reason of the energy and conscientiousness of their proprietors. He especially called attention to the fact that probably none of these men had dreamed of the present proportions of the enterprises with which they had been connected, but had served the future by diligently and honestly meeting the situation before them. He also pointed out that the proper attitude for their successors was for them to consider themselves as the

trustees of the legacy which had been handed down to them, and that the prosperity of any city would be secure just in so far as such a spirit prevailed among those who controlled its industries.

The second speaker, Hon. Charles D. Washburn of the Washburn and Moen Company and president of the board of trustees of the institute, referred to the early steps in providing communications between Worcester on the one hand and Boston and Providence on the other, and spoke of the fact that in the early days the location of industries was often determined by very trifling circumstances. Some of these, while amusing, gave illustrations of the earnestness of spirit of the fathers of industry which, in a large measure, accounted for their ultimate success.

The representative character of the attendance at the meeting was especially noticeable, there being in addition to Worcester and Boston members, a large number from other parts of Massachusetts, as well as some from Rhode Island, New Hampshire and Vermont. Besides Vice-Presidents Ira M. Hollis and I. E. Moultrop, and Calvin W. Rice, Secretary of the Society, several former officers were present.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The annual smoker of the Armour Student Branch was held on September 24, the speakers of the evening being Professors Gebhardt and Paul. Their subject was the Value of Membership in an Engineering Society.

On October 16 a paper on the Power Plant of Marshall Field & Company was read by Chas. W. Naylor, Mem.Am.Soc.M.E. The subject was treated in a nontechnical manner, the elevator system, plumbing and refrigeration being especially discussed.

LEHIGH UNIVERSITY

At a meeting of the Lehigh University Mechanical Engineering Society held October 14, Professors Larkin and Butterfield, Mem.Am.Soc.M.E., were elected faculty advisors of the club. The following subjects were discussed: Refrigeration under Difficulties, R. Rankyn Galloway; Chimneys and Chimney Construction, Russel M. Neff; Dynamometers, Professor Larkin. Professor De Schweinitz and Messrs. Nachman, Nordenholt, Neff, Wright and Gift discussed the papers.

PENNSYLVANIA STATE COLLEGE

On September 26 the Pennsylvania Student Branch held its first meeting of the year in the club room of the Engineering Building. There was a large attendance of students and the work for the year was outlined by H. L. Swift, chairman of the section. In future most of the meetings are to be addressed by student members, after which there will be a general discussion of the subject presented. Professors Moyer, Diemer, Wood and Mease, all members of the Society, gave short addresses at the meeting.

POLYTECHNIC INSTITUTE OF BROOKLYN

Prof. William D. Ennis, Mem.Am.Soc.M.E., was the speaker at the opening meeting of the Polytechnic Institute Student Section, held October 4. He reviewed the work of the mechanical engineering department for the

past year, noted improvements, and referred to the work of some of the more prominent graduates. He described also some of the problems confronting the engineering world of to-day, in particular the utilization of the waste heat in engines of the internal-combustion type.

UNIVERSITY OF CALIFORNIA

At the opening meeting of the year held September 24, the University of California Student Branch elected the following officers to serve for the coming term: chairman, R. Guillon; vice-chairman, G. H. Briggs; secretary, P. H. Landon; treasurer, W. N. Penniman. It was decided to hold meetings every two weeks at which two of the student members are to give short talks upon engineering subjects to be followed by a general discussion by the members. The papers read at this opening session were: The Design of an Intake Manifold for a Gas Engine, J. C. Blair; The Automobile Self-Starter, R. Guillon.

On October 8 two papers were read as follows: Sugar in Honolulu, by G. A. Bush, with special emphasis on the machinery and mills used in this line of industry; Air Brakes, by W. E. Dean, with particular reference to their application to the railroads of to-day.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch was addressed on September 30 by A. L. De Leeuw, Mem.Am.Soc.M.E. His subject was Some Recent Developments in Methods of Cutting Metals, and the lecture was greatly increased in value by the use of unique lantern slides, and the exhibition of tools of his own design. One lathe tool gave white unoxidized chips when used on work having a periphery velocity of 475 ft. per min., taking a 1/16 in. dry cut and feeding 1/12 in.

UNIVERSITY OF MISSOURI

At the October 13 meeting of the University of Missouri Student Branch Prof. J. R. Wharton reported on the Third International Refrigeration Congress held in Chicago last month.

UNIVERSITY OF NEBRASKA

The first meeting of the year of the University of Nebraska Student Branch was called to order on October 7, and was entirely given over to the matter of future plans for the society. J. E. Brown was appointed chairman of a new members committee; J. D. Hoffman, Mem.Am.Soc.M.E., outlined the great benefits to be derived from membership in the Society, and urged all to take an active interest in its work; A. A. Luebs spoke of the value of the Transactions of the Society, and C. A. Hauptman seconded Professor Hoffman's remarks, asking all to help make the section a live one. It was announced that the meetings of December 17 and April 15 would be held before the Engineering Society.

OFFICERS AND COUNCIL

President

W. F. M. Goss

Vice-Presidents

Terms expire 1913

Wm. F. Durand
Ira N. Hollis
Thos. B. Stearns

Terms expire 1914

James Hartness
I. E. Moultrop
H. G. Stott

Managers

Terms expire 1913

D. F. Crawford
Stanley G. Flagg, Jr.
E. B. Katte

Terms expire 1914

Chas. J. Davidson
Henry Hess
Geo. A. Orrok

Terms expire 1915

W. B. Jackson
H. M. Leland
Alfred Noble

Past-Presidents

Members of the Council for 1913

M. L. Holman
Jesse M. Smith
Alex. C. Humphreys
George Westinghouse
E. D. Meier

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

F. R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

W. F. M. Goss, *Chmn.*
Alex. C. Humphreys, *V-Chmn.*
E. B. Katte
E. D. Meier
Geo. A. Orrok
H. G. Stott

STANDING COMMITTEES

Finance

R. M. Dixon (1), *Chmn.*
W. H. Marshall (2)
H. L. Doherty (3)
W. L. Saunders (4)
W. D. Sargent (5)

Meetings

H. de B. Parsons (1), *Chmn.*
L. P. Alford (2)
H. E. Longwell (3)
H. L. Gantt (4)
R. H. Fernald (5)

Publication

G. I. Rockwood (1) *Chmn.*
G. M. Basford (2)
C. I. Earll (3)
I. E. Moultrop (4)
F. R. Low (5)

Membership

Hosea Webster (1), *Chmn.*
Theodore Stebbins (2)
W. H. Boehm (3)
H. C. Meyer, Jr. (4)
L. R. Pomeroy (5)

Library

L. Waldo (4), *Chmn.*
C. L. Clarke (1)
Alfred Noble (2)
W. M. McFarland (3)
The Secretary

Research

R. H. Rice (4), *Chmn.*
L. S. Marks (1)
A. L. De Leeuw (2)
Rolla C. Carpenter (3)
R. D. Mershon (5)

House

E. Van Winkle (1), *Chmn.*
H. R. Cobleigh (2)
S. D. Collett (3)
W. N. Dickinson (4)
F. A. Scheffler (5)

Public Relations

J. M. Dodge (3), *Chmn.*
J. W. Lieb, Jr. (1)
F. J. Miller (2)
W. R. Warner (4)
G. M. Brill (5)

SOCIETY REPRESENTATIVES

Engineering Education

A. C. Humphreys
F. W. Taylor

General Conference Committee of National Engineering Societies

C. W. Baker
E. D. Meier

Council of A. A. A. S.

A. C. Humphreys
W. B. Jackson

John Fritz Medal

H. R. Towne (1)
J. A. Brashear (2)
F. R. Hutton (3)
J. R. Freeman (4)

Trustees U. E. S.

A. C. Humphreys (1)
F. J. Miller (2)
Jesse M. Smith (3)

SPECIAL COMMITTEES

Research Committee, Sub-Committee on Steam

R. H. Rice, *Chmn.*
C. J. Bacon
E. J. Berg
W. D. Ennis
L. S. Marks
J. F. M. Patitz

Power Tests

G. H. Barrus, *Chmn.*
E. T. Adams
L. P. Breckenridge
D. S. Jacobus
William Kent
E. F. Miller
Arthur West
A. C. Wood

Pipe Thread Gages

E. D. Meier, *Chmn.*
George M. Bond
A. M. Houser
J. C. Meloon
Chas. A. Olson
Peter C. Patterson
Henry G. Stott

Student Branches

F. R. Hutton, *Chmn.*
Wm. Kent
Geo. A. Orrok

Research Committee. Sub-Committee on Materials of Electrical Engineering

R. D. Mershon

Note—Numbers in parentheses indicate number of years the member has yet to serve.

Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for Care of Same in Service

J. A. Stevens, *Chmn.*
W. H. Boehm
R. C. Carpenter
Richard Hammond
C. L. Huston
H. C. Meinholtz
E. F. Miller

Tolerances in Screw Thread Fits

L. D. Burlingame, *Chmn.*
Elwood Burdsall
F. G. Coburn
F. H. Colvin
A. A. Fuller
James Hartness
H. M. Leland
W. R. Porter
F. O. Wells

Conference Committee on Engineering Standards

H. G. Stott, *Chmn.*
A. F. Ganz
Carl Schwartz

Society History

J. E. Sweet, *Chmn.*
F. R. Hutton, *Secy.*
H. H. Suplee

Committee on International Engineering Congress 1915

The President
The Secretary
W. F. Durand
R. S. Moore
T. W. Ransom
C. R. Weymouth

Pipe Threads

E. M. Herr, *Chmn.*
W. J. Baldwin
G. M. Bond
S. G. Flagg, Jr.

L. V. Benet, *Paris Rep.*

Flanges

H. G. Stott, *Chmn.*
A. C. Ashton
A. R. Baylis
W. M. McFarland
Wm. Schwanhausser
J. P. Sparrow

Committee on Bureau of Information Respecting Engineering Standards in all Countries

Henry Hess, *Chmn.*
J. H. Barr
Charles Day
C. J. Davidson
Carl Schwartz

Research Committee. Sub-Committee on Safety Valves

P. G. Darling, *Chmn.*
H. D. Gordon
E. F. Miller
F. L. Pryor
F. M. Whyte

Committee on National Museum

E. D. Meier, *Chmn.*
G. F. Kunz
George Mesta
H. G. Reist
Ambrose Swasey

Standard Cross-Section Symbols

H. deB. Parsons, *Chmn.*
F. deR. Furman
A. E. Norton
Bradley Stoughton
John W. Upp

Changes in the Patent Laws of U. S.

W. H. Blauvelt
Carl Thomas
B. F. Wood
Edward Weston
W. E. Winship

Code of Ethics

C. W. Baker, *Chmn.*
C. T. Main
E. D. Meier
Spencer Miller
C. R. Richards

Refrigeration

D. S. Jacobus, *Chmn.*
P. De C. Ball
E. F. Miller
A. P. Trautwein
G. T. Voorhees

Involute Gears

Wilfred Lewis, *Chmn.*
Hugo Bilgram
E. R. Fellows
C. R. Gabriel
C. G. Lanza

Nominating Committee

J. R. Freeman, *Chmn.*
Chas. T. Main
Thos. Morrin
Fred. Sargent
C. C. Thomas

Conservation

G. F. Swain, *Chmn.*
C. W. Baker
L. D. Burlingame
M. L. Holman
Calvin W. Rice

Standardization of Filters

G. W. Fuller, *Chmn.*
Jas. C. Boyd
P. N. Engel
J. C. W. Greth
Wm. Schwanhausser

Standardization of Catalogues

Wm. Kent, *Chmn.*
J. R. Bibbins
M. L. Cooke
W. B. Snow

Chairmen of Sub-Committees of Committee on Increase of Membership

Atlanta, P. A. Dallis
Boston, A. L. Williston
Buffalo, W. H. Carrier
Chicago, Fay Woodmansee
Cincinnati, J. T. Faig
Michigan, H. W. Alden
New York, J. A. Kinkead
Philadelphia, T. C. McBride
St. Louis, John Hunter
St. Paul, Max Toltz
San Francisco, Thomas Morrin
Seattle, R. M. Dyer
Troy, A. E. Cluett

Increase of Membership

I. E. Moultrop, *Chmn.*
F. H. Colvin
H. V. O. Coes
J. V. V. Colwell
R. M. Dixon
W. R. Dunn
J. P. Ilsley
E. B. Katte
R. B. Sheridan
H. Struckmann

SUB-COMMITTEES OF THE COMMITTEE ON MEETINGS

Cement Manufacture

J. G. Bergquist, *Chmn.*
H. J. Seaman, *V-Chmn.*
G. S. Brown
W. R. Dunn
F. W. Kelley
Morris Kind
F. H. Lewis
W. H. Mason
R. K. Meade
Ejnar Posselt
H. Struckmann
A. C. Tagge
P. H. Wilson

Machine Shop Practice

F. H. Colvin, *Chmn.*
E. P. Bullard
L. D. Burlingame
W. L. Clark
A. L. DeLeeuw
W. H. Diefendorf
F. L. Eberhardt
F. A. Errington
A. A. Fuller
H. D. Gordon
H. K. Hathaway
E. J. Kearney
Wm. Lodge
F. E. Rogers
N. E. Zusi

Textiles

C. T. Plunkett, *Chmn.*
E. W. Thomas, *Secy.*
D. M. Bates
John Eccles
E. D. France
E. F. Greene
F. W. Hobbs
C. R. Makepeace
C. H. Manning
H. F. Mansfield

Iron and Steel

Jos. Morgan, *Chmn.*
Thos. Towne, *Secy.*
W. P. Barba
F. F. Beall
Rogers Birnie
A. L. Colby
Julian Kennedy
M. T. Lothrop
W. E. Snyder
J. T. Wallis
R. M. Watt

Depreciation and Obsolescence

Alex. C. Humphreys, *Chmn.*
J. G. Bergquist
C. J. Davidson
A. E. Forstall
F. W. Kelley
H. Struckmann

Air Machinery

F. W. O'Neil, *Chmn.*
H. V. Conrad
William Prellwitz
R. H. Rice

Administration

J. M. Dodge, *Chmn.*
L. P. Alford, *Secy.*
D. M. Bates
John Calder
H. A. Evans
James Hartness
W. B. Tardy
Alexander Taylor
H. H. Vaughan

Industrial Building

F. A. Waldron, *Chmn.*
H. A. Burnham
Charles Day
William Dalton
J. O. DeWolf
C. T. Main

Railroads

E. B. Katte, *Chmn*
G. M. Basford
W. G. Besler
A. H. Ehle
T. N. Ely
W. F. M. Goss
A. L. Humphreys
W. F. Kiesel
W. B. Potter
N. W. Storer
H. H. Vaughan
R. V. Wright

Fire Protection

J. R. Freeman, *Chmn.*
E. V. French, *V-Chmn.*
Albert Blauvelt
F. M. Griswold
H. F. J. Porter
T. W. Ransom
I. H. Woolson

Hoisting and Conveying

R. B. Sheridan, *Chmn.*
C. K. Baldwin
Alex. C. Brown
O. G. Dale
P. J. Fickinger
F. E. Hulett
Spencer Miller
A. L. Roberts
Harry Sawyer

GEOGRAPHICAL SECTIONS OF THE SOCIETY

Milwaukee

Fred H. Dorner, *Chmn*
M. A. Beck
Arthur Simon
Henry Weickel
E. P. Worden

Cincinnati

A. L. DeLeeuw, *Chmn.*
J. T. Faig, *Secy.*
W. G. Franz
G. W. Galbraith
L. H. Thullen

Atlanta

J. S. Coon, *Chmn.*
Park A. Dallis, *Secy.*
George Hillyer, Jr.
Cecil P. Poole
Earl F. Scott

St. Louis

E. L. Ohle, *Chmn.*
F. E. Bausch, *Secy.*
F. N. Jewett
John Hunter
L. C. Nordmeyer

San Francisco

A. M. Hunt, *Chmn.*
T. W. Ransom, *Secy*
W. F. Durand
E. C. Jones
Thos. Morrin

Chicago

Paul P. Bird, *Chmn*
C. W. Naylor, *Secy.*
C. R. Birdsey
W. B. Jackson
A. W. Moseley

LOCAL MEETINGS OF THE SOCIETY

Boston

Henry Bartlett, *Chmn.*
R. E. Curtis, *Secy.*
H. N. Dawes
W. G. Snow
A. L. Williston

New York

F. A. Waldron, *Chmn.*
Edward Van Winkle, *Secy.*
R. V. Wright, *Treas.*
H. R. Cobleigh
J. J. Swan

Philadelphia

D. R. Yarnall, *Chmn.*
W. L. Jones, *Secy.*
J. E. Gibson
Lewis H. Kenney
T. C. McBride

New Haven

E. S. Cooley, *Chmn.*
E. H. Lockwood, *Secy.*
F. L. Bigelow
L. P. Breckenridge
H. B. Sargent

OFFICERS OF THE GAS POWER SECTION

Chairman

F. R. Hutton

Secretary

Geo. A. Orrok

Gas Power Executive Committee

C. H. Benjamin (1)
W. H. Blauvelt (3)
W. D. Ennis (5)
H. J. K. Freyn (1)
F. R. Low (2)
I. E. Moultrop (4)
H. H. Suplee (1)

Gas Power Literature Committee

R. B. Bloemeke, *Chmn.*
A. W. H. Griepe
W. F. Monaghan
W. S. Morrison
S. I. Oesterreicher
H. G. Wolfe

Gas Power Membership Committee

A. F. Stillman, *Chmn.*
H. V. O. Coes
J. H. Lawrence
F. S. King
J. H. Norris
G. M. S. Tait
J. D. Shaw
H. W. Anderson
C. D. Smith

Gas Power Committee on Meetings

Wm. T. Magruder, *Chmn.*
W. H. Blauvelt
E. D. Dreyfus
A. H. Goldingham
Nisbet Latta
H. B. MacFarland

OFFICERS OF AFFILIATED SOCIETY

Providence Association of Mechanical Engineers

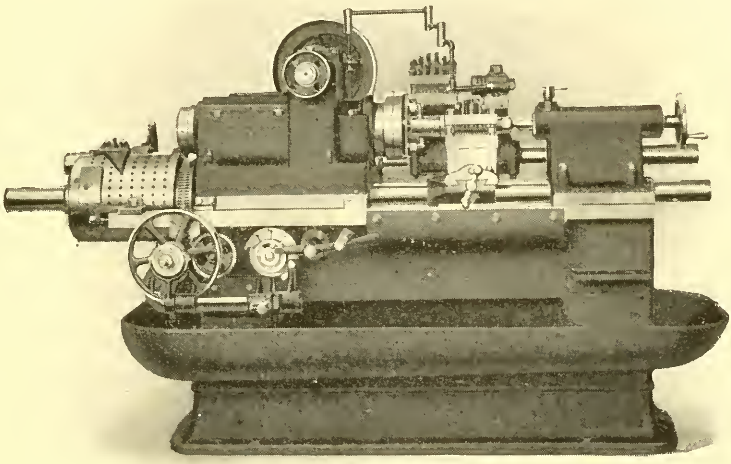
W. H. Paine, *Vice-Pres.*
A. H. Whatley, *Treas.*
J. A. Brooks, *Secy.*

Note—Numbers in parentheses indicate number of years the member has yet to serve.

OFFICERS OF THE STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN	CORRESPONDING SECRETARY
Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	H. E. Erickson	A. N. Koch
Carnegie Inst. of Tech.	Oct. 14, 1913			
Case School of Applied Science	Feb. 14, 1913	F. H. Vose	H. C. Mummert	C. Stemm
Columbia University	Nov. 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen
Cornell University	Dec. 4, 1908	R. C. Carpenter	J. G. Miller	Edw. Mendenhall
Lehigh University	June 2, 1911	P.B. de Schweinitz	W. C. Owen	T. G. Shaffer
Leland Stanford Jr. Univ.	Mar. 9, 1909	W. F. Durand	C. T. Keefer	K. J. Marshall
Mass. Inst. of Tech.	Nov. 9, 1909	E. F. Miller	W. H. Treat	L. L. Downing
New York University	Nov. 9, 1909	C. E. Houghton		
Ohio State University	Jan. 10, 1911	Wm. T. Magruder	R. H. Neilan	R. M. Powell
Penna. State College	Nov. 9, 1909	J. P. Jackson	H. L. Swift	H. L. Hughes
Poly. Inst. of Brooklyn	Mar. 9, 1909	W. D. Ennis	F. D. Peltier	A. Bielek
Purdue University	Mar. 9, 1909	G. A. Young	A. D. Meals	G. F. Lynde
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	E. Kneass	R. F. Fox
State Univ. of Iowa	Apr. 11, 1913	R. S. Wilbur	F. H. Guldner	C. S. Thompson
State Univ. of Kentucky	Jan. 10, 1911	F. P. Anderson	R. R. Taliaferro	F. J. Forsyth
Stevens Inst. of Tech.	Dec. 4, 1908	Alex.C.Humphreys	L. F. Bayer	C. H. Colvin
Syracuse University	Dec. 3, 1911	W. E. Ninde	O. W. Sanderson	R. A. Sherwood
Univ. of Arkansas	Apr. 12, 1910	B. N. Wilson	M. McGill	C. Bethel
Univ. of California	Feb. 13, 1912	Joseph N. LeConte	R. Guillon	P. H. Landon
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	A. O. Hurxthal	E. A. Oster
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	A. H. Aagaard	H. E. Austin
Univ. of Kansas	Mar. 9, 1909	F. W. Sibley	E. A. Van Houten	L. E. Knerr
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	E. H. Bigelow	O. H. Davis
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	R. Runge	L. L. Leach
Univ. of Minnesota	May 12, 1913	J. J. Flather		
Univ. of Nebraska	Dec. 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh
Univ. of Wisconsin	Nov. 9, 1909	A. G. Christie	W. K. Fitch	J. W. Griswold
Washington University	Mar. 10, 1911	E. L. Ohle	D. Southerland	A. Schleiffarth
Yale University	Oct. 11, 1910	L. P. Breckenridge	C. E. Booth	O. D. Covell

High-Production Lathe Work



The Fay Automatic Lathe

Many parts can be finished complete on the Double Spindle Flat Turret Lathe—but many cannot. This may be due to faulty design of the parts, or to a necessity for finishing the work all over. Sometimes the second operation is best done in the same machine, holding it by carefully trued soft chuck jaws. But in many cases the Fay Lathe will prove to be the economical tool.

The Fay Lathe is automatic, and the Fay Lathe is simple—the simplest of the automatics.

The Fay Lathe will turn and face simultaneously, either straight or taper, and will use multiple tools on both operations. It will carry all the tools that the *work* will stand.

The Fay Lathe holds the work on true arbors, on centers. This is the most accurate method of making second operations true with the first, and at the same time furnishes the quickest means ever devised for changing work in the lathe. Many times two pieces may be mounted on the same arbor, doubling the capacity of the machine.

One man runs two machines, and they keep him busy changing work.

INTENSIVE PRODUCTION is the Fay Lathe motto.

COMPANY - Springfield, Vt.

London, E. C.

France, Spain and Belgium: F. Auberty & Co., 91 Rue de Maubeuge, Paris. Italy: W. Vogel, Milan.

"Little David" Riveters

Several radical departures from previous practise make the "Little David" the most effective and durable riveter on the market.

The valve and valve-chest are alongside the cylinder —no matter what the length of the piston used, the valve cannot be injured or the valve action impaired.

The hammer is shorter and lighter than any other riveter—can be worked in closer quarters and more easily handled.

Two through-bolts hold all parts together—the "Little David" is the most accessible riveter made, the only tool needed being monkey-wrench.

Extreme simplicity of design and minimum number of parts, with materials of utmost strength, give the "Little David" exceptional durability.

Send your order for a "Little David" Riveter and convince yourself of its merits by test beside any other riveter you wish.

INGERSOLL-RAND CO.

New York **London**

OFFICES THE WORLD OVER

Compressors **Air Hoists** **Sand Rammers**

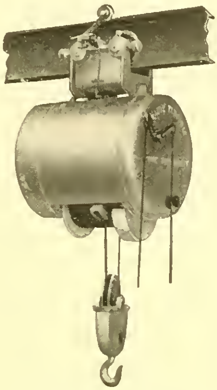
No. PT-25

SPRAGUE ELECTRIC HOISTS

Direct and Alternating Current

CAPACITIES FROM ½ to 6 TONS

ELECTRIC SHOVELS—ELECTRIC WINCHES

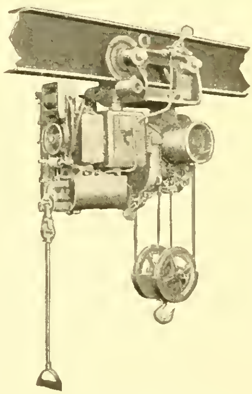


S-1 One Ton Hoist

Sprague Electric Hoists are made in a great number of sizes and designs and are adapted to a large variety of uses. They have proved an invaluable aid to economical operation in manufacturing plants, machine shops, foundries, warehouses and boiler rooms.

Rugged protected construction and simple design eliminate the need of skilled operators and insure the service that means satisfaction.

Ask for Pamphlet No. 90160



W-1 Two Ton Hoist
Rod Operated Controller

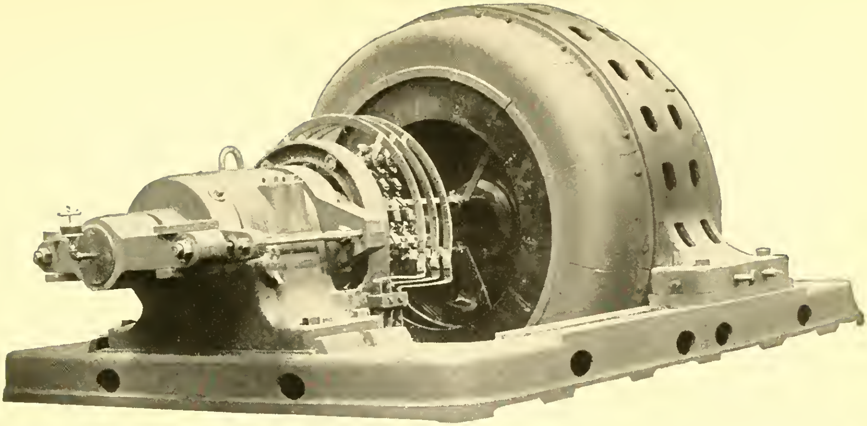
SPRAGUE ELECTRIC WORKS

OF GENERAL ELECTRIC COMPANY

Main Offices: 527-531 West 34th Street, New York, N. Y.

BRANCH OFFICES:

Chicago, Fisher Bldg.; Philadelphia, Witherspoon Bldg.; Boston, 201 Devonshire St.; Baltimore, American Bldg.; Pittsburgh, Oliver Bldg.; Atlanta, Empire Bldg.; San Francisco, Rialto Bldg.; St. Louis, Chemical Bldg.; Milwaukee, Cawker Bldg.; Seattle, Colman Bldg.; Los Angeles, 124 West 4th St.



700 h. p. Westinghouse Motor, equipped with mechanical fuse to protect motor in case rolls break, causing excessive end thrust.

Westinghouse Motors
For Iron and Steel Mill Service

possess features of construction that insure reliable operation. Each motor is given special consideration, and will do its work in the most effective and economical manner.

Some of their important characteristics that *reduce the necessity for attention and the cost of maintenance to a minimum* are:

Great strength to withstand the severe treatment to which they are subjected; complete accessibility and ease of repair; the proper characteristics of torque and speed; large bearings; low brush densities, and dependable lubrication.

The Westinghouse Electric and Manufacturing Company was a pioneer in the development of electric apparatus for the steel and iron industries, and has always been ready not only to meet present requirements but to anticipate and prepare for future needs. The success of this policy is evidenced by the long list of Westinghouse apparatus now doing highly satisfactory service.

Write our nearest office for full details of Westinghouse steel mill motors and their applications.

Westinghouse Electric & Mfg. Co.

EAST PITTSBURGH, PA. — W WESTINGHOUSE ELECTRIC — Sales Offices in 45 American Cities

MACHINE SHOP EQUIPMENT

THE FELLOWS GEAR SHAPER CO.

SPRINGFIELD, VT.

The Gear Shaper cuts the smoothest gears in use, because the cutter is a theoretically correct generating tool and is ground after being hardened. It is also the fastest machine on the market by 25 to 50%. Literature gives reasons in detail.

GEAR SHAPERS

THE GARVIN MACHINE COMPANY

137 Varick St. NEW YORK CITY

Manufacturers of a complete line of Plain and Universal Milling Machines, Screw Machines, Monitor Lathes, Tapping Machines, Duplex Drill Lathes, Speed Lathes, Cutter Grinders, Automatic Chucks, etc.

MILLING MACHINES

THE HARTFORD SPECIAL MACHINERY CO.

HARTFORD, CONN.

Builders of High Grade, Accurate, Special Machinery, Fixtures, Jigs and Tools.

SPECIAL MACHINERY

THE HEALD MACHINE COMPANY

WORCESTER, MASS.

Manufacturers of Grinding Machines. Internal Grinders, Cylinder Grinders, Surface Grinders, Drill Grinders.

GRINDING MACHINES

INGERSOLL-RAND COMPANY

11 Broadway NEW YORK

Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

AIR COMPRESSORS

AIR TOOLS AND HOISTS

JONES & LAMSON MACHINE CO.

SPRINGFIELD, VT.

Manufacturers of the Hartness Flat Turret Lathe; made in two sizes for both bar and chuck work.

TURRET LATHES

THE KING MACHINE TOOL CO.

CINCINNATI, O.

Vertical Turret Machines, 28″ and 34″. Vertical Boring and Turning Machines, 42″ to 84″, inclusive.

HEAVY DUTY BORING MILLS

LATHES

MILLING MACHINES

THE R. K. LE BLOND MACHINE TOOL CO.
CINCINNATI, OHIO

We manufacture a complete line of Heavy Duty Lathes and Milling Machines. They are scientifically designed, so the power is limited only by the strength of the cutting tool. It will pay you to investigate our machines. Catalogue upon request.

MACHINE TOOLS

ENGINEERING SPECIALTIES

MANNING, MAXWELL & MOORE, Inc.
119 W. 40th St. NEW YORK

Are the largest and best known distributors of Machine Tools in the world and carry in stock the product of the foremost designers of the many branches of machine tool building in the United States.

PINIONS AND GEARS

NEW PROCESS GEAR CORPORATION
SYRACUSE, N. Y.

Manufacturers of New Process Noiseless Pinions and also of accurately cut Metal Gears of all kinds.

TURRET LATHES

THE WARNER & SWASEY COMPANY
CLEVELAND, OHIO
BRANCH OFFICES: NEW YORK CHICAGO DETROIT

We offer a most complete line of high-grade Turret Lathes for producing work accurately, rapidly and economically. Our catalog, which describes these machines fully, will be mailed on request.

TAPS AND DIES

WELLS BROTHERS COMPANY
GREENFIELD, MASS.

We make and sell the Little Giant line of Taps, Dies, Screw Cutting Tools and Machinery.

FOUNDRY EQUIPMENT

SAND RAMMERS

AIR TOOLS AND HOISTS

COMPRESSORS

INGERSOLL-RAND COMPANY
11 Broadway NEW YORK

"Crown" Sand Rammers, floor and bench types; "Crown" and "Imperial" Chipping Hammers; "Imperial" Air Motor Hoists, $\frac{1}{2}$ to 5 tons capacity; Air Compressors, twenty types, capacity 8 to 8000 cu. ft. per minute.

FOUNDRY MOLDING MACHINE EQUIPMENT

MUMFORD MOLDING MACHINE CO.
30 Church St., New York — 2007 Fisher Bldg., Chicago, Ill.

Plain Power Squeezing Machines — Split Pattern Vibrator Machines
Jolt Ramming Machines — Pneumatic Vibrators

BLOWERS, FANS, DRYERS, ETC.

PAPERS PUBLISHED BY A. S. M. E.

No. 1320. Commercial Application of the Turbine Turbo-Compressors: R. H. Rice, price, $0.30; No. 830. Compression and Liquidification of Gas: A. L. Rice, price $0.10; No. 804. A Pneumatic Despatch-tube System for Rapid Transportation of Mails in Cities: B. C. Batcheller, price $0.30; No. 1295. The Development of the Air Brake: (Presidential Address) G. Westinghouse, price $0.20.

PAPERS ON AIR COMPRESSORS AND PNEUMATIC TOOLS

STEEL WORKS AND ROLLING MILL EQUIPMENT

PUMPS AND HYDRAULIC TURBINES

PAPERS ON PUMPS AND HYDRAULIC TURBINES

PAPERS PUBLISHED BY A. S. M. E.

No. 381. Standard Method of Conducting Duty Trials of Pumping Engines: Committee Report, price \$0.30; No. 1144. Balancing of Pumping Engines: A. S. Nagle, price \$0.10; No. 1110. Development of Water-wheel Governor: M. A. Replogle, price \$0.20; No. 1113. Turbine Design as Modified for Close Regulation: G. A. Bovinger, price \$0.10.

STEAM ENGINES AND BOILERS

OIL AND GAS ENGINES AND GAS PRODUCERS

POWER PLANT AUXILIARIES AND SPECIALTIES

AIR COMPRESSORS AND PNEUMATIC TOOLS

AIR COMPRESSORS
PNEUMATIC TOOLS

CHICAGO PNEUMATIC TOOL CO.

CHICAGO, ILL.

Manufacturers of "Chicago Pneumatic" Air Compressors and a complete line of Pneumatic Tools and Appliances.

AIR COMPRESSORS
TOOLS
HOISTS AND SAND RAMMERS

INGERSOLL-RAND COMPANY

11 Broadway NEW YORK

Twenty standard Air Compressor types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, ½ to 5 tons capacity; "Crown" Sand Rammers, floor and bench types.

ELECTRICAL APPARATUS

ELECTRIC DRIVE

GENERAL ELECTRIC COMPANY

SCHENECTADY, N. Y.

Generators, motors, Curtis steam turbines, switchboards, transformers, locomotives, lighting equipments, air compressors, electrically heated devices for industrial purposes. Largest manufacturer of electrical apparatus in the world.

GENERATORS
MOTORS
HOISTS
FANS

SPRAGUE ELECTRIC WORKS

of General Electric Co.

527-531 W. 34th St. NEW YORK

Manufacturers of D. C. Generators, Electric Motors, Electric Hoists, Electric Fans, Conduits, Armored Cable, Outlet Boxes, Armored Hose.

DYNAMOS
MOTORS
TRANSFORMERS
INSTRUMENTS

WAGNER ELECTRIC MANUFACTURING COMPANY

ST. LOUIS, MO.

Single-Phase Motors. Polyphase Motors. Transformers, Power & Pole Type. Instruments, a complete line. A. C. Generators. Converters for charging vehicle batteries from A. C. Rectifiers for charging small storage batteries from A. C. Train Lighting (Electric) Equipments. Automobile Self Starters (Electric), etc.

PAPERS ON ELECTRICAL APPARATUS

PAPERS PUBLISHED BY A. S. M. E.

No. 472. Electric Power Distribution: H. C. Spaulding, price $0.20; No. 485. The Electric Railway as applied to Steam Roads: B. J. Dashiell, Jr., price $0.10; No. 845. The Mechanical Equipment of the New South Station: W. C. Kerr, price $1.00; No. 1043. Middlesborough Dock Electric and Hydraulic Power Plant: V. L. Raven, price $0.30.

POWER TRANSMISSION

PAPERS PUBLISHED BY A. S. M. E.

No. 1276. Symposium on Electric Driving in Machine Shop: A. L. DeLeeuw, C. Robbins, J. Riddell and discussion, price $1.10; No. 1335. Variable-speed Power Transmission: G. H. Barrus and C. M. Menly, price $0.10; No. S 47 X. A New Theory of Belt Driving: S. Haar, price $0.20; No. 1239. Transmission of Power by Leather Belting: C. G. Barth, price $0.50.

PAPERS ON POWER TRANSMISSION

ENGINEERING MISCELLANY

ENGINEERING SCHOOLS and COLLEGES

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

Y
621

THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

DECEMBER 1913

35 CENTS A COPY **$3 A YEAR**

ANNUAL MEETING: DECEMBER 2–5
MONTHLY MEETINGS: PHILADELPHIA, DECEMBER 9;
BOSTON, DECEMBER 18

THE NEED FOR COÖPERATION BY THE ENTIRE MEMBERSHIP

The following amendments to the Constitution, to increase the standard of membership will, if favorably acted upon, go into effect at the 1914 Spring Meeting. In publishing these amendments the Committee on Increase of Membership emphasizes the fact that its activities are being directed to securing applications from none but qualified engineers suggested by members of the Society. Every effort is being made by the Committee to impress each member that it is his duty to advise the Secretary of the names and addresses of all desirable members of his acquaintance and also to make a personal effort to secure applications.

The field which remains undeveloped embraces the larger portion of the country. Over 77 per cent of the membership is confined to ten States. We are *the Society of the industries*, yet in many industrial centers we have no adequate representation and we should be at work holding meetings and extending the benefits of the Society to these centers.

AMENDMENTS OPEN FOR DISCUSSION AT ANNUAL MEETING, DECEMBER 3

C-9 A Member shall be an Engineer or Teacher of Applied Science of thirty-two years of age, or over, and shall have been in the active practice of his profession for at least ten years and in responsible charge of important work for five years, and shall be qualified to design as well as to direct engineering work. Fulfilling the duties of a Professor of Engineering who is in charge of a department in a college or school of accepted standing shall be taken as an equivalent to an equal number of years of active practice. Graduation from a school of engineering of recognized standing shall be considered as equivalent to two years of active practice.

C-11 An Associate-Member shall be a professional engineer not

less than twenty-seven years of age, who shall have been in the active practice of his profession for at least six years, and who shall have had responsible charge of work as principal or assistant for at least one year. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

H. V. O. Coes	R. M. Dixon	E. B. Katte
F. H. Colvin	W. R. Dunn	R. B. Sheridan
J. V. V. Colwell	J. P. Ilsley	H. Struckmann

Chairmen of Sub-Committees

Atlanta, Park A. Dallis
Boston, A. L. Williston
Buffalo, W. H. Carrier
Chicago, Fay Woodmansee
Cincinnati, J. T. Faig
Cleveland, R. B. Sheridan
Michigan, H. W. Alden
New York, J. A. Kinkead
Philadelphia, T. C. McBride
St. Louis, John Hunter
St. Paul, Max Toltz
San Francisco, Thos. Morrin
Seattle, R. M. Dyer
Troy, A. E. Cluett

DECEMBER 1913 VOL. 35 No. 12

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

CONTENTS

The Journal is published monthly by The American Society of Mechanical Engineers.
Price, 25 cents a copy, or $2 a year, to members and affiliates of the Society; 35 cents a copy or $3 a year to all others. Postage to Canada, 50 cents additional; to foreign countries, $1 additional.
Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

COMING MEETINGS OF THE SOCIETY

December 2-5, *Annual Meeting*, Engineering Societies Building, New York.

December 9, *Philadelphia, Pa.* Topic: How Far Shall Judgment be Exercised in the Interpretation of Engineering Specifications? Twenty-minute papers from various prominent engineers.

December 18, *Boston, Mass.* Paper: Methods of Protecting Large Electric Transmission Systems, G. A. Burnham.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 DECEMBER, 1913 NUMBER 12

ANNOUNCEMENT

Beginning with the January 1914 number, The Journal will be issued in a new and enlarged form in the standard 9 by 12 size now so generally adopted by the leading technical journals in this country, and to some extent abroad. This development of The Journal is the result of an extended study by the Publication Committee, upon request of the Council, of the whole question of the publications of the Society. It is designed to make The Journal a distinctive publication, adequate to the needs of the large membership with its diversified interests.

The activities of the Society are rapidly increasing in many fields, meetings are held in a dozen cities, and a number of committees are engaged upon reports and investigations, all of which has resulted in a constantly increasing amount of material valuable for publication. It is the purpose of the Journal to present this material to the membership month by month, in convenient and attractive form. The Foreign Review not only will be continued, but in so far as feasible will be extended. The advance papers for the meetings will be printed as usual in pamphlet form in octavo size for distribution before and at the meetings.

FIFTH NATIONAL CONSERVATION CONGRESS

The Society was represented at the Fifth National Conservation Congress, held in Washington, D. C., on November 18, 19 and 20, 1913, by the chairman of its Committee on Conservation, Dr. Geo. F. Swain, and by Charles Whiting Baker and Calvin W. Rice, Secretary, members of the committee, as well as by General Wm. H. Bixby, United States Engineer, and Dr. Joseph A. Holmes, director of the Bureau of Mines.

Dr. Swain, besides being chairman of the Society's committee, is chairman of the Water Power Committee of the Congress, about whose report centered the major portion of the discussion of the Congress. As this committee was unable to agree on all features of the majority report, there was also a minority report, as well as a memorandum of those features on which the committee was not in accord. The latter document was finally adopted by the Congress.

Over a thousand delegates were in attendance and extraordinary interest was displayed in all features of the program.

WASHINGTON SOCIETY OF ENGINEERS

The delegates at the Congress representing the Society attended a dinner given by the Washington Society of Engineers on Tuesday evening, November 18. This Society comprises in a manner similar to the engineering societies in Boston and St. Louis the members of the four national engineering societies. Addresses were made at the dinner by Dr. Swain, Dr. Holmes, John Hays Hammond, members of the Society, and by Admiral Baird, Dr. Wylie and John Foord. Running through the addresses was a note of encouragement to the engineer to take a more prominent part in public affairs.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. The Membership Committee and in turn the Council urge the members to assume their share of the responsibility of receiving these candidates into the membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the

good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before January 10, 1913:

Abbott, Edward R., N. Y. Rep., The Taft-Pierce Mfg. Co., New York
Alexander, Durand C., Foreign Rep., Niles-Bement-Pond Co., New York
Allison, James E., Cons. Engr., 300 Security Bldg., St. Louis, Mo.
Angell, Harry J., With Goulds Mfg. Co., Seneca Falls, N. Y.
Bassett, Royal M., Mgr. Chicago Office, Murphy Iron Wks. of Detroit, Chicago, Ill.
Bauhan, Alexander E., Station Supt., Pennsylvania Water & Power Co., Holtwood, Pa.
Behney, Charles C., Mech. Engr., Simplex Valve & Meter Co., Philadelphia, Pa.
Berges, Arthur H., Draftsman, Chicago & Western Indiana R. R. Co., Chicago, Ill.
Billings, John H., Instr., University of Missouri, Columbia, Mo.
Boles, Chalmers B., Engr., Sulzberger & Sons Co. of Amer., Chicago, Ill.
Brown, James W., Engr., Cadillac Motor Car Co., Detroit, Mich.
Clark, Edward H., First Asst. Engr., Mass. Inst. of Tech., Boston, Mass.
Dean, Peter P., Sales Engr., Diehl Mfg. Co., Elizabeth, N. J., and New York
Flexer, Samuel E., Mech. Engr., Clinchfield Portland Cement Corp., Kingston, Tenn.
Fisler, Amos C., Designing & Erecting Engr., Simplex Valve & Meter Co., Philadelphia, Pa.
Goetz, Arnold H., Asst. Mgr., Kroeschell Bros. Ice Mch. Co., Chicago, Ill.
Graves, Louis W., Member of Firm, Samuel M. Green Co., Springfield, Mass.
Gref, William H., Engr., Gibbs & Hill, New York
Hamilton, John R., Master Mech., Automatic Sprinkler Co. of Amer., New York
Holley, George M., Pres., Holley Bros. Co., Detroit, Mich.
Isert, J. G. Hunt, Genl. Supt., and Mech. Engr., W. T. Pyne Mill & Supply Co., Louisville, Ky.
Kennedy, Samuel S., Cons. Engr., Winnipeg, Manitoba, Canada
Krabbe, Adolph F., Ch. Engr. & Genl. Supt., Olympic Portland Cement Co., Ltd., Bellingham, Wash.
Lindholm, Arthur C., Tool Designer, Metropolitan Engrg. Co., Brooklyn, N. Y.
Merrill, Albert A., Aeronautical Engr., Mass. Inst. of Tech., Boston, Mass.
Millard, Reginald W., Genl. Mgr., Foster, Merriam & Co., Meriden, Conn.
Mitchel, Albert H., N. Y. Rep., The Taft-Pierce Co., New York
Moore, Francis G., Mech. Engr., J. H. Williams & Co., Brooklyn, N. Y.
Nelis, Joseph J., Sales Rep., The Babcock & Wilcox Co., Cincinnati, Ohio
Newton, Nathan Alexander, Sales & Cons. Engr., National Transit Co., Oil City, Pa.
Ophuls, Fred, Cons. Refrigerating Engr., 50 Church St., New York
Orbison Thomas E., Asst. Engr. to Thos. W. Orbison, Cons. Engr., Appleton, Wis.
Pfeiffer, Alois J. J., Cons. Engr., 3 St. Helens Pl., London, E. C., England
Phipps, Walter, Pres. & Supt. of Production, Massnick Phipps Mfg. Co., Detroit, Mich.
Riley, Lewis A., 2nd, Cons. Mech. Engr., 95 Liberty St., New York
Ripple, Paul W., Power & Equipt. Engr. for various traction companies, New Haven, Conn.
Rosenthal, Emanuel, Instr. of Manual Training, Board of Education, New York
Sahmel, Viggo, Cons. Engr., 50 Church St., New York
Schoenky, Otto B., Genl. Foreman, Car Dept., Southern Pacific Co., Sacramento, Cal.
Scott, Howard B., With Chalmers Motor Co., Detroit, Mich.
Sears, Harold R., Draftsman, Racine, Truscott, Shell Lake Boat Co., Muskegon, Mich.
Selfridge, Samuel W., Experimental Engr., American La France Fire Eng. Co., Inc., Elmira, N. Y.
Shedd, Thos. C., Asst. in Mech. Engrg., Brown University, Providence, R. I.
Simonson, George M., Elec. Draftsman, California State Dept. of Engrg., Sacramento, Cal.
Taylor, DeWitt, McC., Asst. Instr. in Mech. Engrg., Mass. Inst. of Tech., Boston, Mass.
Tomlines, Thomas L., Industrial Engr., Stebbins Engrg. & Mfg. Co., Watertown, N. Y.
Wood, Gleason, Asst. Supt., Waltham Watch Co., Waltham, Mass.
Wynne, John H., Mgr., American Locomotive Co., Paterson, N. J.

PROMOTION FROM JUNIOR

Briggs, Leroy E., Staff Engr. in private laboratory, Thos. A. Edison, Orange, N. J.
Freeman, Perry J., Mech. Engr., Gullett Cotton Gin Co., Amite, La.
Johnson, James F., Director State Trade School, Bridgeport, Conn.
Marquis, Franklin W., Prof. of Steam Engrg., Ohio State Univ., Columbus, Ohio

Swanberg, Floyd L., Secy. The D. T. Williams Valve Co., Cincinnati, Ohio
Wilson, George S., Asst. Prof. of Mech. Engrg., Washington Univ., Seattle, Wash.

SUMMARY

New applications	48
Promotion from Junior	6
Total	54

ANNUAL REPORTS OF STANDING COMMITTEES

REPORT OF THE FINANCE COMMITTEE

Appended will be found the certified report of the examination of the accounts of the Society, made by Messrs. Struss & Company, for the fiscal year of the Society ending September 30, 1913.

Your Finance Committee reports that the income of the Society for the year ending September 30, 1913, was $117,106.44; the total expenditures, $109,393.68, leaving an excess over income of $7712.76, which it is recommended be turned into the reserve fund, and that all appropriations in excess of actual expenditures be cancelled.

Your Committee further thinks it should be thoroughly understood by the various committees that their appropriations should not be exceeded without the approval of the Council, and that expenditures in excess of appropriations will not be considered with favor by the Council of the Society.

Further, your Finance Committee recommends for the budget for the year to end September 30, 1914, as follows:

Finance Committee	$22,375
Membership	2,100
Increase of Membership Committee	2,250
House Committee	2,250
Library Committee	5,000
Committee on Meetings	6,500
Publication Committee	54,750
Research Committee	100
Power Tests Committee	1,500
Council	6,870
Sales	6,000
John Fritz Medal	125
Boiler Specifications Committee	1,000
Total	$110,820

It is estimated that the income will be $119,800.

It should be understood that as the year progresses, if the income

shall give evidence of exceeding the estimate, then in cases of necessity, appropriations will be increased.

Respectfully submitted.

R. M. DIXON, *Chmn.*	*Finance Committee*
W. H. MARSHALL	
H. L. DOHERTY	
W. L. SAUNDERS	
W. D. SARGENT	

APPENDIX TO REPORT

October 17, 1913

MR. R. M. DIXON,
CHAIRMAN, FINANCE COMMITTEE

Dear Sir:

In accordance with your instructions, we have examined the books and accounts of The American Society of Mechanical Engineers, for the twelve months ended September 30, 1913.

The results of this examination are set forth in the three exhibits, attached hereto, as follows:

Exhibit A Balance Sheet, September 30, 1913

Exhibit B Income and Expenses, for the twelve months ended September 30, 1913

Exhibit C Receipts and Disbursements for the twelve months ended September 30, 1913

We hereby certify that the accompanying Balance Sheet is a true exhibit of its financial condition as of September 30, 1913, and that the attached statements of Income and Expenses, and Receipts and Disbursements are correct.

Respectfully submitted,

WM. J. STRUSS & CO
Certified Public Accountants

EXHIBIT A

BALANCE SHEET, SEPTEMBER 30, 1913

ASSETS

Equity in Society's Building (25 to 33 West 39th Street)	$353,346.62	
Equity one-third of cost of land (25 to 33 West 39th Street)	180,000.00	
		$533,346.62
Library Books	13,000.00	
Furniture and Fixtures	5,000.00	
		18,000.00
Stores, including Plates and Finished Publications		14,982.85

New York City $3\frac{1}{2}\%$ Bonds 1954 (Par $35,000)		30,925.00
Cash in Banks representing Trust Funds		34,212.40
Cash in Banks for General Purposes	5,193.12	
Petty Cash on hand	500.00	
		5,693.12
Accounts Receivable		
Membership Dues	10,185.00	
Initiation Fees	2,360.00	
Sales of Publication, Advertising, etc.	12,950.44	
Total		25,495.44
M-A Social		181.31
German-Resolution Fund		.60
Advanced Payments		2,066.26
		$664,903.60

LIABILITIES

Certificates of Indebtedness		$68,100.00
Funds		
Life Membership Fund	$35,386.07	
Library Development Fund	4,902.71	
Weeks Legacy Fund	1,957.00	
		42,245.78
Dues paid in Advance		2,637.09
Initiation Fees uncollected		2,360.00
Initiation Fees paid before due		75.00
Unexpended Appropriation 1911–1912		473.28
Unexpended Appropriation 1912–1913		2,586.66
Unappropriated Revenue		5,126.10
Reserve (Initiation Fees)		50,527.45
Surplus in Property and Accounts Receivable		490,772.24
		$664,903.60

EXHIBIT *B*

INCOME

Membership Dues	$69,078.22	
Sales, Gross Receipts	8,796.90	
Advertising	37,336.96	
Interest and Discount	1,894.36	
		$117,106.44

EXPENSES

Finance Committee	$22,881.65	
Membership Committee	3,280.21	
Increase of Membership Committee	3,802.55	
House Committee	2,203.78	
Library Committee	4,143.72	
Meetings Committee	6,754.21	
Council Committee	7,965.11	
Publications Committee	51,743.42	
Research Committee	34.01	
Power Test Committee	1,000.00	
History	51.85	
Sales Expenditures	5,027.83	
John Fritz	505.34	
Total		109,393.68
Excess of Income over Expenses		$7,712.76

EXHIBIT *C*

RECEIPTS

Membership Dues[1]	$64,385.99	
Initiation Fees[2]	17,320.00	
Membership Dues, Initiation Fees, paid in advance	2,859.84	
Sales of Publications, Badges, and Advertising, etc.	47,366.60	
Subscription to Land Fund	110.00	
Interest	3,309.80	
	135,352.23	
Cash in Banks and on hand, September 30, 1912	32,993.10	
		$168,345.33

DISBURSEMENTS

Disbursements for General Purposes	$121,739.81	
Certificates of Indebtedness redeemed	6,700.00	
	$128,439.81	
Cash in Banks and on hand, September 30, 1913	39,905.52	
		$168,345.33

[1] All membership dues are considered income as soon as due and the difference between the item of membership dues under income and the same under receipts, is the amount due in that particular year that was not collected.

[2] Initiation fees by order of the Council are immediately placed in the reserve fund, no portion being applied to income. Certificates of indebtedness for the land of the Engineering Societies Building are being paid off at the rate of $6000 annually, from the amount received for initiation fees, which is an investment of the initiation fees rather than an expense.

REPORT OF THE HOUSE COMMITTEE

In addition to the routine matters generally assigned to the House Committee, this Committee was entrusted with the management and conduct of the Tuesday evening President's reception, on the occasion of the Annual Meeting of 1912.

In February a complete inventory of the pictures, equipment, books, stores and publications, belonging to the Society, was prepared, and recommendations were made as to how this inventory should be continued and kept up-to-date.

Plans have been started to procure portrait busts in bronze of our two honorary members in perpetuity, and a study of the bust of Alexander L. Holley has been placed in the council room for criticism.

In March the Society received the John Fritz bequests, including the tall clock, the Irving Scott loving cup, medals and diplomas belonging to the late John Fritz. The clock has been installed in the entrance hall, and the Committee has under consideration the display of other memorabilia befitting Mr. Fritz's memory.

Some improvements have been made in the filing systems to take care of new and additional records, and new cabinets have been purchased on the recommendation of the Secretary.

The Committee has continued to procure honorary members' pictures; and, at present, prospects seem to indicate the substantial completion of this collection during the coming year.

Respectfully submitted,

Edw. Van Winkle, *Chmn.*
H. R. Cobleigh
S. D. Collett
W. W. Dickinson
F. A. Scheffler

House Committee

REPORT OF THE LIBRARY COMMITTEE

An important step in the administration of the library has been taken during the past year in the placing of the library under the management of one board. This Board comprises five members from each of the three Founder Societies, and through its work a greater unification of the methods of administration will be possible.

The collections contained in the library make it now probably the best engineering library in the United States, if not in the world. During the past three years about 9000 volumes have been added, largely by gift or exchange, and the list of current periodicals has

grown to about 700. Our Society has added to its section of the library 1103 volumes and 168 periodicals, and has had 316 volumes rebound.

A generous gift of more than a hundred books from the library of the late Charles Wallace Hunt, Past-President of the Society, has recently been received from Mrs. Hunt, and has been placed in stacks accessible to the public. Its many volumes of technical value form a distinct and valuable addition to the library.

The Charles Wallace Hunt Fund, created by a number of Mr. Hunt's friends as a tribute to his memory, has thus far contributed $173.68 for books on the subject of transmission machinery and transmission of material. The treasurer's report is as follows:

HUNT MEMORIAL FUND

Subscriptions received (June 26, 1911, to Aug. 18, 1911)		$400.36
Interest on unexpended balances		10.74
Total receipts		$411.10
Expenses, postage, printing and binding testimonial	$70.27	
Books purchased to date on order of librarian on subject of transmission machinery and transmission of material	103.41	
Total expenditures		173.68
Balance on hand September 26, 1913		$237.42

The increase in the number of readers has been extremely gratifying. During the past year there has been an increase from 10,000 to 12,000, making an average attendance of about 40 for each working day, and from present indications the number will continue to increase. It is interesting to record that through the correspondence division assistance has been rendered in connection with many engineering projects, such as the Panama canal, the New York aqueduct, the subway construction, the Woolworth building, Grand Central Station, and that, in fact, there are few large industrial corporations which have not received some help from the library.

The reference work has extended the library's usefulness as far as Patagonia, Johannesburg and Australia. This branch of the library's service, by far its most active and important function at the present time, has been wholly developed during the past three years and has been of the greatest value to many members, especially those living at a distance. As the system is now operated, any person, whether a member or not, may have references compiled for him to

the literature upon any subject upon which he desires information. If the sources are not available in the city in which he is located, copies may be made for him, and if the references are to articles published in a foreign language, they will be translated if desired. Copies are made of all such searches, and there are now on file between 400 and 500 of these lists. References prepared by the library have often been used as evidence in large patent suits.

The library contemplates the establishment of branch libraries, or at least the strengthening of the engineering resources of public libraries existing in various cities. Many members of the founder societies have been generous in donations of sets of periodicals and of society transactions, and there have thus accumulated a number of duplicate sets. For such a purpose as that suggested these gifts will be gladly welcomed.

The past year has seen the compilation and publication of the list of serials and society publications, and the preparation of a union list of the technical periodicals in seven of the libraries of the city of New York.

Respectfully submitted,

Leonard Waldo, *Chmn.*
C. L. Clarke
Alfred Noble
W. M. McFarland
The Secretary

Library Committee

REPORT OF THE COMMITTEE ON MEETINGS

The total appropriation made for the use of this Committee was $5500. Although the individual members of the Committee worked diligently and did not incur any unnecessary expense, nevertheless the activities of the Society which formed this Committee's duties cost more than the appropriation by about $1500. This deficit was caused by the expenses of the Annual and Spring Meetings which exceeded the appropriation named by the Council for that purpose.

The duties of this Committee do not cease, but are continuous throughout the year. The policy of the Committee has been in accordance with the resolution passed by the Council in January 1913, wherein it was asked that each committee of the Society keep in close touch with the Council in order that there may be a full coöperation.

Early in the year Mr. Willis E. Hall was forced to resign through

business engagements and his place has been filled by Mr. L. P. Alford.

It is with considerable satisfaction the Committee on Meetings is able to report on the valuable work being done for the Society by its sub-committees. Special activity has been promoted by the Committee on Cement Manufacture, by the Committee on Railroads, by the Committee on Fire Protection, by the Committee on Industrial Buildings and by the Committee on Machine Shop Practice. The good work that can be done by these sub-committees when properly organized cannot be over-estimated and such committees should be encouraged by the Society. At the present time there are eleven sub-committees in existence.

The Council appointed a special committee to coöperate with the American Institute of Electrical Engineers in order that there might be a joint meeting between the two societies in December 1913. The Committee on Meetings acquiesced and did what it could to further such a joint meeting. Later in the year the Institute of Electrical Engineers determined that it was not possible to have a meeting in December. In consequence the Committee on Meetings is making arrangements for the Annual Meeting along lines similar to those which have been customary for years past.

As a result of its experience in conducting meetings, the Committee recommends a change in the manner of printing and distributing advance papers to be read at the Annual and Spring Meetings. These now appear in The Journal in complete form during a period of three or four months before a meeting, and the cost is rapidly increasing owing to the increase in the circulation of The Journal.

Only an occasional discussion is received as a result of the published papers. The most effective method for securing discussion is by means of personal letters to engineers known to be interested, accompanied by copies of the papers.

The Committee believes it would be advantageous to have grouped in one number of The Journal in advance of a meeting, brief abstracts of all the papers to be given at that meeting. The members could then see at a glance what papers were to be discussed, and could quickly determine the nature of their contents and the author's conclusions. At the meetings all the papers will be on hand in pamphlet form.

The Committee therefore recommends the following plan:

a That papers be published complete in pamphlet form in

advance of a meeting, but not in The Journal prior to the meeting.

b That abstracts of perhaps 500 words each, or about ten per cent of the entire paper, of all the papers for a given meeting be grouped and published in one number of The Journal at least one month in advance of the meeting.

c That announcement be made each time by circular, return postal, or in The Journal, that copies of complete papers on any subject will be sent free to any member asking for them for the purpose of contributing a discussion.

d It is assumed that after the meeting, the papers and discussion will be printed and distributed in substantially complete form, either in The Journal or in Transactions.

The Committee endorses the policy established last year of individual payments by those participating in the social entertainments of the Annual and Spring Meetings of the Society.

Respectfully submitted,

H. de B. Parsons, *Chmn.*
L. P. Alford
H. E. Longwell
H. L. Gantt
R. H. Fernald

Committee on Meetings

REPORT OF COMMITTEE ON MEMBERSHIP

During the past year the Committee on Membership has held nine meetings for the transaction of its work.

The number of applications acted upon is as follows:

Applications pending Oct. 1, 1912	163
Applications received during fiscal year Oct. 1, 1912 to Sept. 30, 1913	1046
Total	1209

On these applications the following action was taken:

Recommended for membership	868
Withdrawn for various reasons	2
Deferred indefinitely	7
Deferred for further information	3
Applications pending receipt of endorsements from required number of references	329
Total	1209

It was also voted to reinstate 8 members.

In accordance with the amendments to the Constitution which became effective at the Spring Meeting last May the method of electing members has been changed from that of election by the membership at large to election by the Council. This method obviates the necessity of publishing the expensive professional service sheet, the last issue of which was forwarded to the membership last March and consisted of a 208-page book containing the records of 619 candidates for membership.

In 1911–1912, 694 candidates were voted upon at an expense of $3567.16, or $5.14 per candidate. During the year just completed 868 candidates have been recommended for membership at a cost of $3280.21, or $3.78 per candidate, thereby reducing the cost 26 per cent.

On the Professional Service Sheets issued in October 1912 and March 1913, 929 candidates appeared, but those included in the October 1912 issue were passed upon by the Membership Committee during the fiscal year of 1911–1912.

In the same way a portion of the 868 candidates passed upon in the fiscal year 1912–1913 will not be voted upon by the Council until the year 1913–1914.

Respectfully submitted,

Hosea Webster, *Chmn.*
Theo. Stebbins
W. H. Boehm
H. C. Meyer, Jr.
L. R. Pomeroy

Membership Committee

REPORT OF THE PUBLICATION COMMITTEE

In the publication of Transactions and The Journal the Publication Committee has to handle an increasing amount of material from year to year, and during the past year it has in consequence been necessary to resort to condensation of papers and discussion to a greater extent than usual. Even with such condensation the point has been reached where it is impossible to issue the Transactions at an expense of less than $10,000, and next year it is expected that this will increase to $11,000.

For the third consecutive year The Journal has been self-supporting and besides publishing reports of all the meetings held in different cities, has continued the Foreign Review and printed considerable other matter not incorporated in the annual volume of Transactions.

The Journal is thus becoming more and more the representative publication of the Society.

The Committee has prepared copy for an adequate index to the first thirty volumes of Transactions, which is now ready to put into the hands of the printer. When issued this will fill a real need, since only twenty-five of the volumes have heretofore been covered by a general index, which was, moreover, incomplete.

In accordance with a resolution of the Council asking the Committee to look into the whole situation of the publications of the Society and to report their conclusions, this matter has been studied in its various phases with a great deal of care, with a view to adapting the publications to the present and future needs of the Society.

Before the establishment of The Journal it was the custom of the Society to issue the papers in pamphlet form previous to the two meetings held each year, which were then the only meetings. At the end of the year, an annual volume was issued containing these same papers with the discussion upon them. With the introduction of The Journal papers were issued previous to the meetings, both general and local, and as soon as possible thereafter the discussion appeared. Of late a condensation of these same papers and discussion has been necessary in a number of instances before their reproduction in Transactions, and lack of space has also compelled the omission of a few.

The Committee believes that under present conditions the monthly publication of a great engineering society should be of much broader scope and that the reports of meetings and accounts of Society affairs in general should become the predominating features. The papers should be published in the numbers following a meeting, instead of in advance, enabling the papers and discussion to be brought together in the form of reports, and presented in the same manner in which any technical journal would deal with the affairs of the day. Under such an arrangement of papers and discussion not only would the value of The Journal to the membership be enhanced, but the arrangement would be such that it could take the place of Transactions.

In regard to the latter, the arguments in favor of issuing The Journal in such form that it will itself consist of the Transactions, thus making unnecessary the duplicate publication of part of the matter appearing in The Journal, are as follows:

1 The declining value to the average member of the Society of such a publication as Transactions, which at best

covers but a narrow part of the broad expanse of the full activity of the Society, as compared with the increasing value of such a publication as The Journal, which besides doing just what the Transactions does, also covers every other activity of the Society.

2 The increasing cost of Transactions, due to the increase in editorial work necessary to reduce to the limits of one volume the large number of papers now being read all over the United States in the various branches of the Society as well as at the Annual Meetings. Should the alternative be adopted, namely of a two-volume edition, the cost would then be prohibitive.

3 The advantage to the membership of having these funds available for other and more useful purposes.

4 The elimination of the economic waste now incurred by publishing in two places the papers presented before the Society, a practice which has never been indulged in by the great European Societies, and which is customary with only three other American societies.

The Committee is of the opinion that The Journal can be made to render a greater service to the membership and would be more inviting to the reader if issued in the standard 9 by 12 size already used by some technical societies, and now coming to be adopted so generally by the technical press in this country and to some extent abroad. Substantially this size is used by such leading professional societies of the world as the Verein deutscher Ingenieure, the Institute of Naval Architects, the American Medical Association, and the American Society of Naval Architects, and has recently been adopted by the American Institute of Architects and the British Institution of Electrical Engineers. The journals of the Verein and of the American Medical Association are the most successful professional journals in the world.

As a result of their investigations, the Committee believes that the needs of the Society would best be served by adopting the following methods of publication:

1 Papers to be printed in pamphlet form (9 x 6 size) complete in advance of a meeting, but not published in The Journal prior to the meeting.

2 Abstracts (of perhaps 500 words each) of all the papers for a given meeting to be grouped and published in one number of The Journal at least one month in advance of the meeting.

3 Announcement to be made each time by circular, return postal or in The Journal, that copies of complete papers on any subject will be sent free to any member asking for them.

4 That papers and discussion be published together in issues of The Journal following the meeting at which they are presented.

By this procedure there will appear in The Journal at an earlier date than is possible in the annual volume of Transactions the revised papers and discussion given at meetings, and when published in this way The Journal will contain the Transactions of the Society in complete form and will be worthy of binding and preservation by the membership.

Respectfully submitted,

G. I. Rockwood, *Chmn.*
G. M. Basford
C. I. Earll
I. E. Moultrop
F. R. Low

Publication Committee

REPORT OF THE RESEARCH COMMITTEE

The activities of the Research Committee have been confined this year to the Sub-Committee on Safety Valves, P. G. Darling, Chairman.

This sub-committee has been engaged during the past year in gathering all available information on the design, construction, and rating of safety valves for steam boilers. The work has been done through correspondence with individuals and companies who are specialists in this field, and the responses have been very encouraging. The committee expects in the near future to be able to proceed with the work of formulating rules governing the design of safety valves and the rating of valves of a given size.

Respectfully submitted,

R. H. Rice, *Chmn.*
L. S. Marks
A. L. De Leeuw
Rolla C. Carpenter
R. D. Mershon

Research Committee

TASK SETTING FOR FIREMEN AND MAINTAINING HIGH EFFICIENCY IN BOILER PLANTS

By Walter N. Polakov

ABSTRACT OF PAPER

The determination of the practical maximum economy of boiler room operation is the subject of this discussion. The question is twofold in its nature: (*a*) how to obtain this maximum economy of operation, and (*b*) how to secure the permanency of the results attained. The first part of the question involves the theoretical research into the problem which embraces: (*a*) analysis of variables, (*b*) limiting influence of variables on maximum, and (*c*) dependence of results from time rate. This part deals with methods of experimental determination of maximum theoretical efficiency obtainable under given conditions, and incidentally refers to the graphical method of study of boiler trials as applied to actual examples of the writer's tests.

The well-known falling short of test results in everyday performances forms the connecting link with the second part of the paper, and it is shown how the results of theoretical research can be made practically obtainable in regular service. This embraces the methods employed by the writer in studying the psycho-physiological element of the problem. In order that the prescribed conditions be maintained and the desired results of high economy of operation be accomplished, not spasmodically, but day in and day out, the task put before men ought to be (*a*) possible, and (*b*) desirable.

The possibility of accomplishment of task is governed by (*a*) proper coördination of conditions and supplies with power demand and existing facilities; (*b*) proper guidance of men in their work; (*c*) proper balance of strain during the work and regain of physical losses of the individual during intervals between working periods. Part *c* complements the common method of time studies, with a new method of physical studies of the effect of work on the health of workingmen and a method of scientific determination of length of working day.

The desirability of accomplishment of a task set within men's possibilities requires the study of: (*a*) physical stimuli, (*b*) psychical stimuli, and (*c*) social stimuli. To the group (*a*) is referred payment of bonus, better surroundings, shorter hours, sanitary conditions, etc. To the group (*b*) factors like sporting spirit, confidence in records, relationship with management, desire to study and advance, etc., are referred. To the last group (*c*) belong such stimuli (favorable or not) as attitude of fellow workmen, of trade unions and socialist party, of members of the family, and condition of labor market, legal regulations, etc. To the above plan are added examples of records from practice, and description of methods greatly simplifying the working out of records and logs.

TASK SETTING FOR FIREMEN AND MAINTAINING HIGH EFFICIENCY IN BOILER PLANTS

By Walter N. Polakov, Philadelphia, Pa.

Member of the Society

The object of this paper is to outline a method for the accurate determination and permanent attainment of maximum economy in daily boiler room practice in the power plant by the task-setting method. The problem is two-fold: First, the determination of the conditions which will result in a maximum operating economy; and second, the determination of the factors which will secure the permanent attainment of these best conditions. The writer recently had an opportunity to reorganize the power plant of a large public utility company, and the methods employed to determine the tasks for the firemen and to attain the improvement in results which they represent in everyday running, met with such success that a report on the subject seems to be warranted.

2 The engineering function of a boiler plant is deliberately to convert the thermochemical energy latent in fuel into the volume energy latent in steam, through a process of trans-power, while the commercial function is to generate steam of required quality and in a required quantity at the lowest cost compatible with the circumstances. The problem before the management, however, is to determine and provide the necessary and sufficient conditions, the fulfillment of which will bring about and assure the permanency of the desired predetermined results.

3 The degree of engineering perfection in a boiler plant is generally reckoned in terms of thermodynamic efficiency, but this criterion alone is both inaccurate and insufficient. It is inaccurate inasmuch as the inherent thermodynamic efficiency of the plant, if determined either by calculation or by experiment under ideal con-

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

ditions, is not attained in practice; if determined from everyday performance it is short by some unknown quantity, depending upon the variable "human element." It is insufficient since the conception of thermodynamic efficiency of a boiler plant does not include the "time element" which is the chief determining factor in our industrial, commercial and social lives. Thus, the thermodynamic efficiency can represent correctly the degree of perfection of the whole plant only if supplemented by correction factors taking into account the human and time elements, and is only one of many factors to be considered in the problem of reckoning the industrial efficiency of a plant.

4 As in differential calculus, the place of maxima depends upon the limiting conditions of variables and constants, so in our problem the proper and complete solution can be found only by strict observance of the rules of scientific investigation, and the steps to be taken in this research work can be grouped chiefly as follows: (*a*) analysis of elements, (*b*) study of limiting effects of variable and constant elements on the maximum efficiency of partial processes, and (*c*) determination of maximum effect and the corelation of determining factors. When in this manner we learn what can be accomplished and what are the conditions *necessary* for it, we have further to investigate whether these conditions are *sufficient*. Our knowledge would be insufficient if we did not consider the element of human will to attain the task set, and the stimulating factor to keep permanently at work the power of will to maintain these known favorable conditions.

5 The well-known fact that the high thermal efficiency attained by experts during the boiler tests is seldom maintained in everyday practice is due to gross neglect on the part of the management to:

- *a* record the conditions causing the high efficiency during the test
- *b* instruct the men how to regulate these conditions in order to duplicate the test results, and
- *c* provide an incentive to the men for striving for the purpose desired by the management or owners

To this we may add that in most instances there is no assurance or proof that the high test efficiency was really the highest attainable.

6 The work of testing steam boilers as it is usually conducted is not infrequently done by young college graduates or sometimes by the boiler room force, even in the plants of conservative and reputable companies. The data thus obtained is seldom reliable and com-

plete, and even if every factor, however insignificant, is measured and recorded the results are almost equally worthless, except that occasionally such tests disclose a serious leak somewhere and enable steps to be taken to remedy the isolated cause of loss. As a rule these evaporative tests are of no further use than to satisfy the owner's curiosity or fancy to see mere figures of efficiency and load and sometimes heat balance. As a consequence the work of testing boilers is brought in this country to disrepute, to the auxiliary role of a "selling trick."

7 A mere heat balance is unable to furnish answers to the many questions of utmost importance for determining of conditions for the most economic steam generation. Lack of positive, well grounded principles as well is responsible repeatedly for faulty construction of furnaces and arrangement of baffles and gas passages. The average data of most tests are of very little value inasmuch as such factors as attention and skill of firemen are dumped into the same heap with the factors of boiler and furnace construction, and of properties of fuel. Furthermore, the most reliable test data are of very limited practical value unless they are so analyzed that the dependence of certain phenomena upon definite factors is clearly revealed.

8 What is needed most is a method of boiler test research which will (*a*) establish a theoretical standard for each partial process and allow the determination of partial and ultimate efficiency, and (*b*) establish the influence of such conditions as variation of specific heat of gases depending upon their composition and temperature, radiation of furnace, variation of efficiency of heat transmission, variation of volume of gases in passages with different conditions of combustion, various rates of firing and percentage of infiltration of air, and influence of superheat on the economy of the process. The graphical method of studying boiler performance as suggested several years ago by Professor Grinevetski, fairly satisfies these requirements, and the diagrams thus obtained, representing the working process of a steam boiler, are the most reliable tools in the hands of an investigator for setting the task for boiler operation independent of the skill of the casual firemen during the test, and plainly establishing the relation between the causes and effects.

9 The Grinevetski method of graphical analysis is one that is particularly useful in showing the interrelations of these important governing variables of the steam boiler. By it the relations between the temperatures of the gases and the heat contained in them at various temperatures are shown in the form of parabolic curves, as

are similarly the relations between the heat in the gases and the area of heating surface, and also the relations of radiated heat to the heating surface. The development of this method of analysis is explained in Appendix No. 1, in which the two examples of the curves (Figs. 13 and 14), namely, for tests Nos. 2 and 6, made at the Warrior Ridge power plant of the Penn Central Light & Power Company, are described. Its application to practice, as outlined

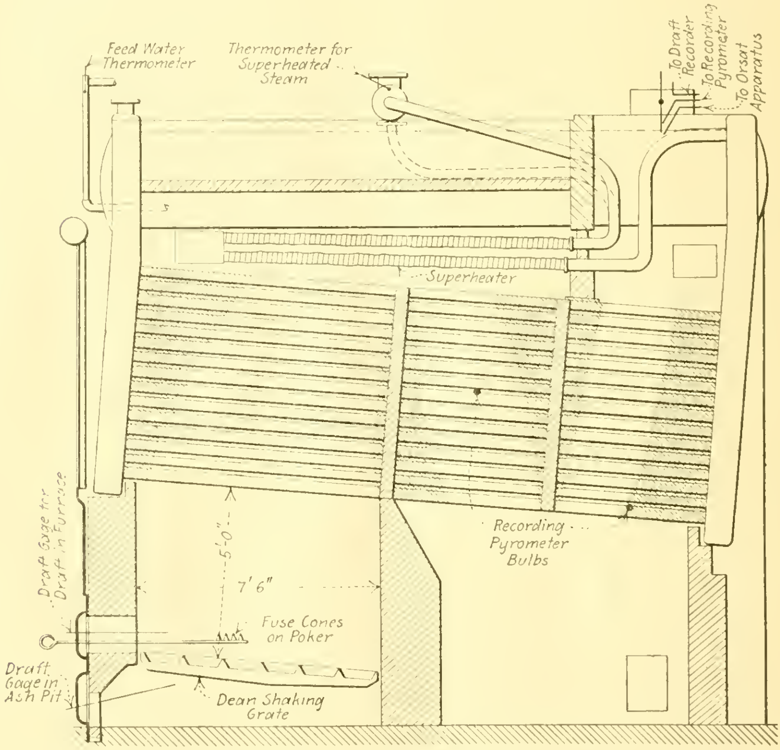


Fig. 1 Longitudinal Section of Test Boiler showing Locations of Instruments and Dead Corners in Gas Passages

in the following paragraphs, is virtually the basis of the method of work discussed in this paper. The tests referred to above are among a number that were made early in 1913, two of which, tests Nos. 1 and 2 (see Appendix No. 3) were for the purpose of ascertaining the economic result of the operating method in vogue at the plant before betterment work was started and to determine any possible weaknesses of the practice. Test No. 1 is merely a record of obser-

vations made over a period of 80 days to determine the result of former operating conditions, while test No. 2 was a deliberate attempt to make a favorable showing under those conditions. The efficiency observed in test No. 2 was 67.94 per cent. Tests Nos. 3, 5 and 6 were run to study the effects of the various changes made in operating conditions and for the standardization of practice, while test No. 6, which is analyzed graphically in Fig. 14, was a check test on our standard conditions. It showed the efficiency of boilers, furnaces and grates as 76.03 per cent when operating at 89.6 per cent of rating, while its official repetition under a load of 115.5 per cent of rating, showed an efficiency of 77.66 per cent. Tests Nos. 8, 10a and 10b were made principally for the selection of coal.

10 The advantages of graphical study of boiler performance were thus plainly demonstrated and the efficiency figure of 77.66 per cent was accepted as a practical maximum of thermal efficiency for this boiler, furnace and grate. As a method, it demonstrates with an appealing clearness the main conditions and results of the process of combustion and steam generation. As a matter of fact the characteristic curve does not change materially in shape for different boilers nor vary at all for the same boiler and same fuel, and thus the problem resolves itself into mere calculation of scales, shifting of coördinates and measurement of projections.

11 The next question therefore was to ascertain what would be the reasonable limit below which no fireman should allow his efficiency to drop. In this we had to consider the factors beyond the control of firemen, viz.: sudden fluctuation of load and unpracticability in that particular instance to analyze gases every 3 minutes; drop of attention every 40 minutes for the period of 11 to 20 minutes and effect of cooling off heating surface and furnace walls during the cleaning of fires (the allotted time for this was set on time studies as 18 minutes per 100 sq. ft. of grate surface). On the other hand there was made a correction for blowing off the boiler once every 24 hours, which credited the boiler with so much metered water and debited it with so many heat units in the same amount of water at the boiler temperature. As a result of these investigations and studies, it was found that the standard for the task should be set at 70 per cent combined boiler and grate efficiency.

12 In this connection it is interesting to note that all officials of the concern and the representative of the boiler maker, considered the task on this basis too high and that accomplishment of it would be out of the question. The only argument that obtained its tem-

porary approval was that it was easier to reduce the task in the future if not feasible to accomplish than to make it higher. The fourth month of the task work, however, proved that 73.1 per cent of boiler and grate efficiency was permanently maintained, effecting for the company a gross saving of approximately 25 per cent on the fuel bill alone. This was accomplished, and we would like to emphasize the fact, without heavy capital investment for physical improvement of equipment like automatic stokers, special grates, force

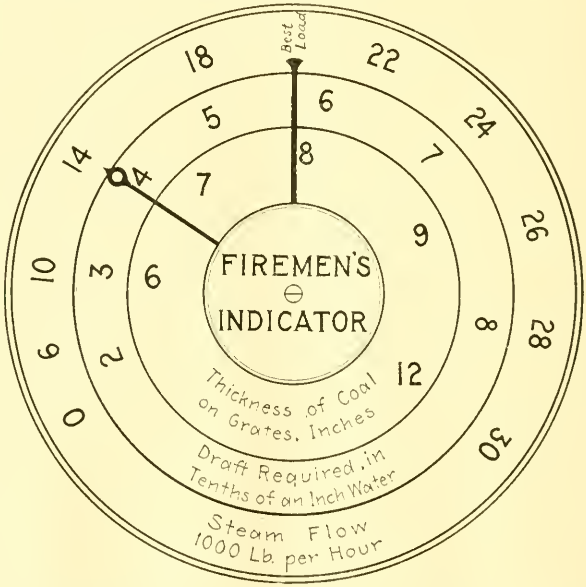


Fig. 2 Dial of Steam Flow Meter with Special Scales for Use as Fireman's Indicator

draft fans, soot blowers, etc. The only expense was for a few instruments for the guidance of the firemen in their work of living up to their instruction card.

13 After the test results were carefully studied and the practical maximum efficiency established, it was an easy matter, by referring to the test logs, to standardize the conditions of firing which necessarily result in generating steam at a desired degree of efficiency. In this, however, difficulty was encountered in that, like the great majority of boiler plants in this country, these boilers were equipped with only pressure gages and water columns, and it was necessary to provide instruments for certain important measurements. As

with other conditions equal, the weight of steam is in direct proportion to the weight of fuel burned, the first instrument necessary for informing the firemen as to how much coal to put in the furnace is a meter indicating the output of the boiler. But as this proportion is constant only at a given condition of combustion, the firemen have to be informed at all times as to what these conditions are. Since complete combustion requires a strictly defined quantity of air per pound of fuel of given composition, we have to know:

a Composition of fuel

b Rate of firing, lb. per sq. ft. per min.

c Rate of air supply, lb. per sq. ft. per min.

In most cases it is possible to obtain fuel of practically uniform analysis, and in addition to have the analysis report within 3 hours from the time of the delivery of coal to the bin, so that the first variable may be taken as a constant. As to the rate of firing, this is indicated by the steam flow meter inasmuch as conditions of combustion are uniform. Then, our last variable, the quantity of air to be supplied per minute to the furnace, is the factor which we have to control.

14 As long as the infiltration of air remains constant (it should be as near to zero as possible) and the cross-section of air ducts or pit doors is constant, the variable elements are the velocity of air and its specific weight. The specific weight being a function of temperature, calls probably for not more than two corrections per year for winter and summer average temperatures in the fire room. Thus we have a practical solution of the problem in the indications of a draft gage. Draft, i. e. vacuum over fires, is usually measured in such small fractions of an inch of water column that, considering the resistance of flow of the gases through the boiler as constant for each rate of firing, it is more convenient to take readings at the uptake. From our definition of the draft as vacuum, it follows that, in itself, it is no indication as to quantity of air flowing through the fuel bed and must always be considered in relation to the resistance offered by the layer of burning coal. Careful tests can easily establish the desired interrelation between the quantity of air and thickness of fires, or a duplex draft gage can be advantageously used.

15 This reasoning leads to the conclusion that for practical guidance the fireman needs at least three instruments:

a Indicating steam meter

b Draft gage

c Indicator for the coördination of the condition of firing with the load carried by the boiler at any moment.

In his experience the writer found that the well-known General Electric steam flow meter of the indicating type could easily and satisfactorily serve the third mentioned purpose. The writer arranges on the dial of the steam flow meter an inside dial, as shown in Fig. 2, with numbers indicating the required thickness of fuel bed corres-

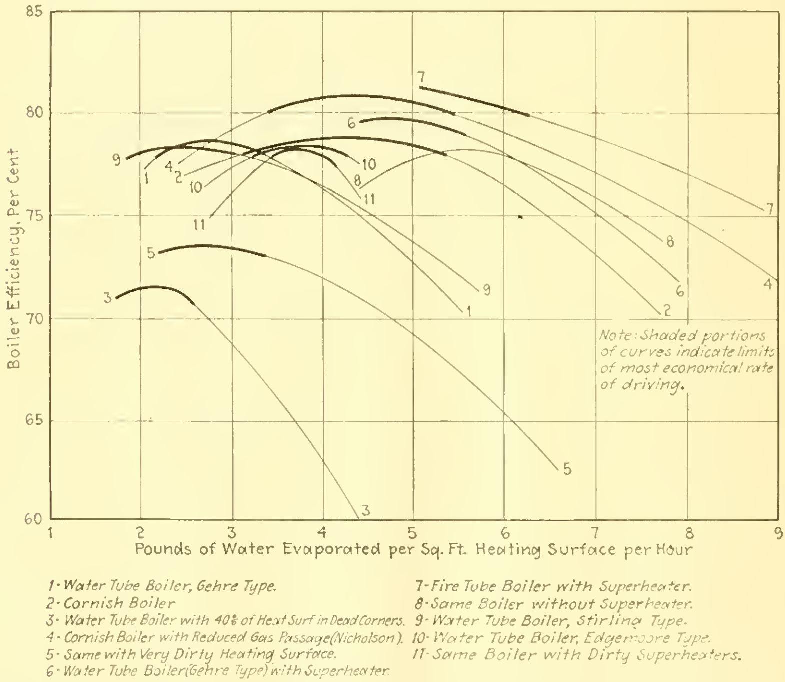


Fig. 3 Diagram showing Most Economic Loadings for Various Types of Boilers

ponding to the number of pounds of steam drawn from the boiler and a third dial with numbers indicating the draft which is necessary and sufficient to supply the required quantity of air for the combustion at a rate called for by the indicated steam demand. Thus, if the pointer, as in Fig. 2, shows that steam is flowing from the boiler at a rate of say 14,000 lb. per hour, the fireman will know that the figure 4 under the pointer on the middle scale means that a draft of 0.4 in. of water is needed and that the location of the pointer on the inner scale between the figures 6 and 7 calls for a thickness of fires of from 6 to 7 in.

16 The next information vitally important for the fireman is the frequency at which his furnace must be coaled to keep the fires in best condition. The method adopted by the Italian Navy is accepted by the writer as most satisfactory, consisting chiefly in bell signaling at intervals in proportion to the load carried by the boilers, which signaling is regulated by clock mechanism connected with a flow meter. For use in a boiler house where a number of batteries are fired independently and it was desirable to eliminate the variations of load among them, a modification of this method was devised to equalize the driving of each furnace. For this purpose the counter of the feedwater weigher, supplying water to the entire boiler house, rings the bell every time a certain number of thousand pounds of water is fed to the boilers, thus giving notice to the firemen that an adequate number of shovelsful must be thrown into each furnace. This number is easily determined since the weight of a shovelful of coal is known and the rate of apparent evaporation at the given condition of firing is a constant.

17 In a public utility plant the load carried by the boilers varies considerably, as a rule, not only throughout a day but often within an hour, in which it may swing from maximum to minimum, or vice versa. This condition was particularly noticeable in the plant of the Penn Central Light & Power Company at Warrior Ridge, Pa., supplying power to the consumers as different in character as residential lighting, coal mines, textile mills, quarries and interurban railroads. While with a number of small steam generating units the peak periods and off-peak valleys in the load curve do not affect the rate of driving individual boilers since the number of boilers put into service can easily be changed, a widely fluctuating load within a short period has its limiting influence on the attainable efficiency of steam generation. The time element in boiler performance, or, in other words, the time required for generation of a certain quantity of steam with the greatest economy, is of utmost importance. Some idea of the relation of factor of thermal efficiency to the rate of driving for boilers of different designs is given in Fig. 3, a chart compiled from data gathered from the experience of the writer.

18 Here again we are confronted with the fact that the thermal efficiency is not a final criterion and it is often the case that high rate of driving, although thermally efficient, is too expensive on account of special costly devices necessary for forcing the boilers or uneven distribution of work on the men requiring extra men idle part of the time. Unwarranted fixed charges in one case and a high

pay roll in the other make it financially desirable to limit the output of the boilers. Again, in other cases low rates of driving are abandoned irrespective of the thermodynamic advantages on the strength of financial impossibility for the concern to add new units.

19 The above considerations require for proper solution of the problem a scrupulous research into interdependence of: (*a*) Variation of fixed charges with various time units required for production of a unit of volume energy in shape of steam; (*b*) variations of thermal efficiency with the variations of the above time unit; (*c*) variations of pay roll, etc.; (*d*) variations of the cost of maintenance, etc.; (*e*) physical limits affecting the quality of steam, as size of superheaters which at certain point are unable to absorb the heat due to slow convection of heat by dry steam; and (*f*) physical limits of space. Thus, while the increase of output up to certain limit usually increases the thermal efficiency, after this point it begins to fall. But it is in most cases erroneous to assume this maximum efficiency point as a best load to operate the boilers at, due to the complexity of the above mentioned limiting factors.

20 From this short reference to the limiting influence of the variable factors on the final commercial economy we may pass to the problem of final criterion for the determination of the task. The process of steam generation can be conveniently represented in the form of the equation:

$$E_s = E_f \times E_p \times E_m \times E_g \times E_c \times E_t$$

where E indicates the ratio of utilization, or efficiency, and the corresponding indexes signify as follows: s steam generation, f financial outlay, p purchase of fuel, etc., m attendance of men, g gasification of fuel in furnace, c combustion of gases, and t transmission of heat of gases to the boiler water and steam.

21 In a given plant E_f is constant; E_p is to be determined previous to the setting of the task for men; the quality, characteristics and cost of fuel are so strictly governed by the construction of the furnace and boiler, by the available draft, and methods of stoking by the coking or baking peculiarities of fuel, that from the few varieties of fuel available on the market, the selection of the most suitable is a mere computation of the cost of fuel for generating say 1000 lb. of steam of given quality. This computation, however, shall follow, not precede the determination of the best condition of combustion with each of the varieties of fuel permanently available on the local market at a given cost including freight rates.

22 Efficiency of gasification of fuel E_g is a variable which in its

turn is limited by: (*a*) rate of firing, (*b*) fusing and clinkering quality, (*c*) size of fragments of fuel, (*d*) method of firing, (*e*) frequency of leveling or shaking, and (*f*) thickness of coal bed (provided the design of furnace or grates remains unchanged).

23 Similarly E_c, efficiency of combustion of gases liberated from the fuel, is limited by several factors: (*a*) composition and nature of volatile matters, (*b*) proportion of gases to oxygen supplied by air, (*c*) volume of gases developed per unit of time, (*d*) velocity of gas currents, (*e*) volume of furnace, (*f*) distance of the combustion zone from the heating surface, and (*g*) thickness of fuel bed, or length and shape of torch (for gaseous and liquid fuels).

24 Finally E_t, efficiency of transmission of heat, even in the boiler of a given design, varies widely and is positively determined by: (*a*) velocity of hot gases, (*b*) volume per unit of time intact with unit of area, (*c*) temperature of the gases, (*d*) pressure inside of the boiler, (*e*) insulating coating of cool gases, soot and scale deposits, and (*f*) desired quality of steam.

25 A method of computing these partial efficiencies is self-evident:

$$E_g \text{ (efficiency of gasification)} = \frac{\text{heat value in refuse from N lb. coal burned}}{\text{heat value in N lb. of coal}}$$

$$E_c \text{ (efficiency of combustion)} = \frac{\text{heat developed, computed from gas analysis}}{\text{heat in fuel less heat in refuse}}$$

$$E_t \text{ (efficiency of heat transmission)} = \frac{\text{heat in steam generated by 1 lb. fuel}}{\text{heat available for heating surface}}$$

In the last case the temperature of the boiler itself at the given pressure could be taken into consideration as well as the temperature required for the creation of draft. In other terms this equation can be represented as the function of temperatures.

$$E_t = \frac{T - t_s}{T - t_k}$$

where

T = temperature of the gases of combustion

t_s = temperature of gases leaving boiler at uptake

t_k = temperature of boiler water

26 The information these formulae convey is of the greatest importance for influence of judgment as to what partial efficiency and to what extent it could be sacrificed in order to arrive at a desired high standard and meet all other practical requirements and conditions. But, it must not be forgotten that they contain no time ele-

ment in their composition. To introduce this criterion the boiler output per hour shall be recognized in either of the methods:

$$\text{thermal boiler horsepower} = \frac{\text{heat absorbed by boiler per hour}}{1{,}980{,}000 \text{ ft-lb.}}$$

or

$$\text{mechanical boiler horsepower} = \frac{p \times v}{23{,}760{,}000}$$

where

p = steam pressure absolute per sq. in.

v = steam volume generated in cu. in. per hour

27 This general outline of a method of analyzing the limiting values of variables and determination of conditions necessary for the attainment of certain predetermined results would be incomplete without a reference to the practice of studying the influence of individual variables. The writer is convinced that any boiler trial conducted with the most scrupulous care may leave obscure the influence of a number of the above mentioned limiting factors as well as leave the question uncertain whether the maximum practical efficiency or capacity was really obtained during the test and whether or not the various conditions as observed are necessary and sufficient to duplicate the results at any time. The writer maintains, that as long as the question is not to attain accidentally a mark set at random, but clearly and fully to determine all conditions necessary for maximum economy of operation, for the purpose of setting definite standards, it is imperative to conduct a number of separate observations, though of short duration, dealing in each case with one and only one variable in order to find its limiting effects. Only through an a posteriori method of reasoning, through a wide induction from a sufficient number of particular observations, may the probability that is tantamount to certainty be attained.

28 Ascertaining finally the physical elements of the efficiency equation and its value and, eliminating the constants beyond our control, we ultimately obtain a reliable basis for judging the efficiency of the "human element" of the problem which could be expressed as

$$E_m = f(e)$$

and its limit is reached when the difference between the theoretical efficiency of the process and its actual accomplishment is zero.

29 We now come to the question of how to use this available knowledge based on theoretical research in such a way as to secure the best results practicable in regular service by the task method.

In setting a task for firemen, it remains to be determined what the scope of the task shall be. In order to accomplish the purpose it devolves upon the management to accumulate the detailed and exact knowledge of the most favorable conditions to attain results and make it possible and desirable for every employee to live up to them. It is for the employee, on the other hand, either to create or maintain such conditions as are required in the management's specific instructions.

30 Various schemes have been used as the basis of task setting for firemen which to the writer's knowledge have always created dissatisfaction. Certain of these are as follows:

a The cost of steam generated was used for the basis of the task in the boiler room of a large cement plant, and a premium offered for the reduction of this cost, but as firemen have no control over the purchase of fuel, maintenance of equipment, etc., this task involved the standardizing of conditions of combustion, for which no instruments were provided and no definite standard or aim was set before them, and the scheme was soon abandoned.

b The high percentage of CO_2 in flue gas was adopted as a task basis for firemen in several plants, but the men were not trained nor were they even shown how to obtain it. When they occasionally attained the mark, the question remained undecided whether high percentage of carbon dioxide was coincident with the most economical steam generation or not, and the method proved generally unsatisfactory.

c A high percentage of CO_2 and low percentage of combustible in the ashes, were factors upon which another attempt was made to specify more definitely the firemen's task. The question remains, however, whether the conditions which the firemen must observe to attain the task and produce gas rich in carbon dioxide and an ash with little carbon, are actually the best for transmitting the heat of the gases to the water and steam and whether at any load the same standard is equally beneficial.

d A limit on coal consumption as a task for railroad firemen was favored at one time. This idea, probably the most ridiculous and illogical, soon demonstrated its own weakness and has been almost entirely abandoned.

31 The lack of analytic thought in these instances is remarkable; such important factors as condition of equipment, variable quality of fuel, weather conditions, necessary instruments, complete record keeping, thorough instructions, etc., were disregarded or undervalued. The common cause of failure of such schemes has been the desire to make a short cut and jump over all preliminary studies, and save the time and trouble of training men in a systematic and thorough manner how to accomplish the task set for them. Should such training be undertaken with bona fide intentions, the instructors themselves would be compelled to discontinue the training as soon as they discovered that the control of the conditions affecting the results is beyond the men.

32 The question of measuring the effect of task accomplishment can be approached from either end, but it is more convenient to figure out the result, and if this is below the standard, turn to the records of conditions and there locate the discrepancy between the required results and those obtained. A gage for measurement of the degree of fulfilment of task conditions set is offered by the factor of thermal efficiency of grate, furnace and boiler which is

$$\frac{\text{heat transferred to steam}}{\text{heat available in fuel}}$$

This measurement involves several corrections for factors beyond firemen's control and neither ratio of apparent evaporation nor boiler efficiency nor efficiency of combustion alone are anywhere near sufficient for the purpose of judging the efficiency of the work of men.

33 Actually to calculate the efficiency of the boiler, furnace and grate is a tedious and comparatively long procedure, and is never made in power plants for a day, shift, fireman or gang of firemen working in team. The writer in his capacity of consulting engineer devised and introduced a comparatively simple method of obtaining a complete record of firemen's performance and to figure their efficiency. This method, which has been in vogue for over a year at the central station at Warrior Ridge, Pa., requires the following record data:

- *a* Coal records from store issue tickets and coal passers reports compiled every eight hours
- *b* Heat value of fuel determined by bomb calorimeter and value of coal in B.t.u. known for each coal pocket
- *c* Amount of water fed to boiler (banked boilers fed separately) ascertained for the same periods

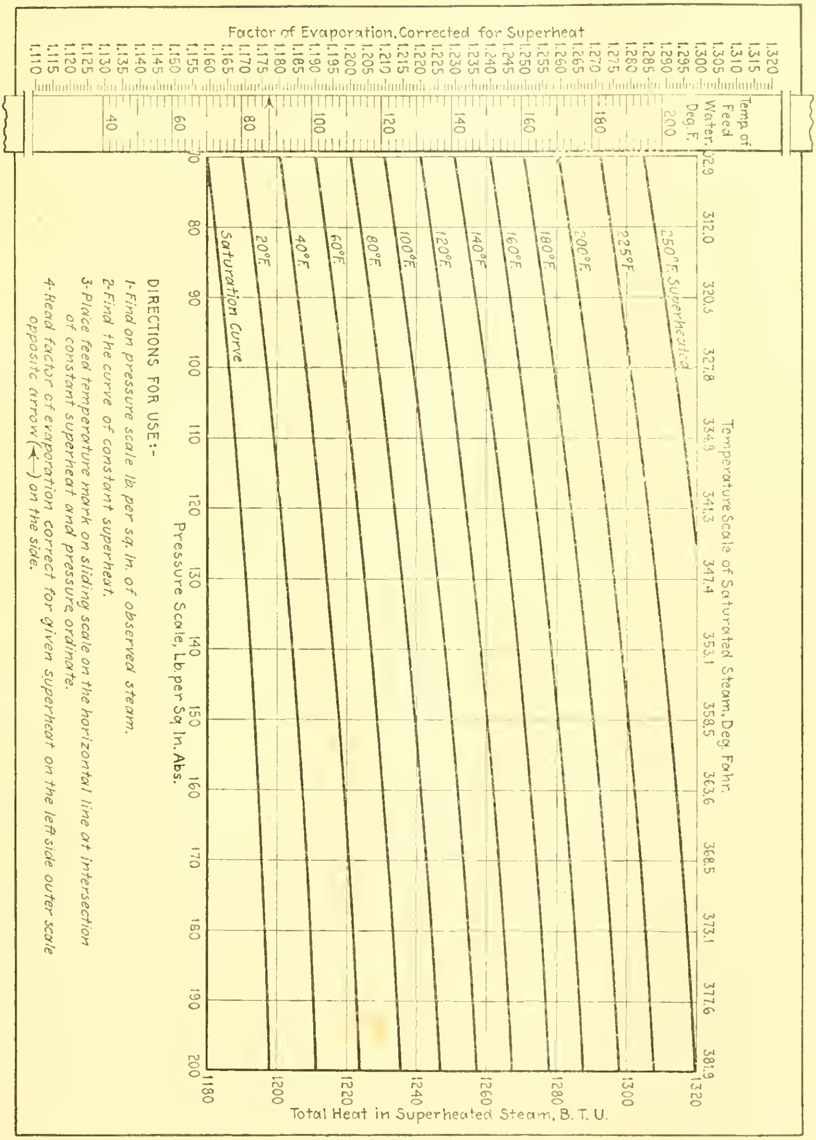


Fig. 4 Slide Rule Used for Determination of Factors of Correction

d Temperature of feedwater recorded

e Steam pressure recorded

f Degrees of superheat recorded

34 These data are turned over to the station clerk who proceeds as follows:

a From the slide rule shown in Fig. 4, he ascertains the factor of evaporation (corrected) on the basis of absolute boiler pressure, temperature of feed and temperature of superheat

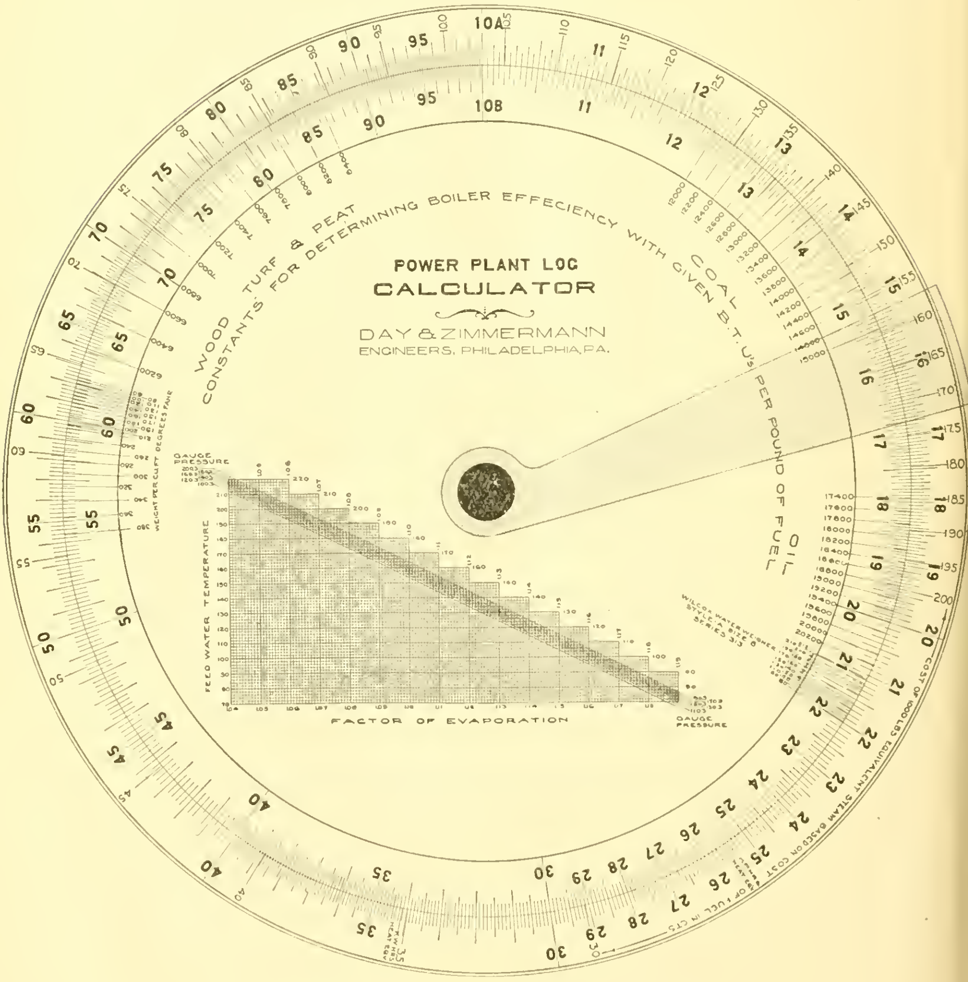


Fig. 5 Power Plant Log Calculator

b By means of the power plant log calculator, Fig. 5, he determines

1. actual evaporation ratio during each watch or per each man
2. factor of evaporation during each watch or per each man

9	6	19/13
MONTH	DAY	YEAR

I HAVE INVESTIGATED AND REPORT BELOW THE
CAUSE OF LOST BONUS

DEPT. Electr.
DISTR. War. Ridge

BY O. Hawn ON JOB Firing

CONDITION Draft was set wrong
Due to leak in draft gauge

RESPONSIBILITY IS ALLOCATED TO Maintenance Man

REMEDY ATTENDED TO BY ME ~~SUGGESTED FOR APPROVAL~~ Ordering Repair

S. D. Port
SIGNED

9	12	19/13
MONTH	DAY	YEAR

I HAVE INVESTIGATED AND REPORT BELOW THE
CAUSE OF LOST BONUS

DEPT. Electr
DISTR. War. Ridge

BY D. M. Pope ON JOB Firing

CONDITION Extra boilers were shut down after midnight.
Unexpected load came, too high rate of firing.

RESPONSIBILITY IS ALLOCATED TO Switch-board operator

REMEDY ATTENDED TO BY ME ~~SUGGESTED FOR APPROVAL~~ Reprimanded

S. D. Port
SIGNED

FIG. 6 EXAMPLES OF FORM USED FOR RECORDS OF CAUSE OF LOST BONUS

3. equivalent evaporation during each watch or per each man
4. efficiency of steam generation per watch or per each man
5. cost of fuel per 1000 lb. of steam per watch or per each man

He then enters the results of computation on the daily power plant

report form (see Figs. 11 and 12). The whole procedure takes on the average 18 minutes of the clerk's time, for whom, incidentally a specific task is assigned and sufficient hourly bonus offered for, its fulfilment.

35 Every case of failure on the part of any fireman to secure on his watch the combined boiler, furnace and grate efficiency of 70 per cent or above is immediately investigated by studies of other records and recording charts of draft, temperature of escaping gases, nature of boiler refuse, etc., and if no reason can be found there, an exam-

FORM 6A561A

DAILY BONUS SLIP CHARGE

DATE *September*

NAME *J. Dearing* NO.

DISTRICT-PLANT *Warrior Ridge*

HOURS DAY WORK	*4*
HOURS BONUS WORK	*4*
HOURS BONUS EARNED	*1*
TOTAL HOURS FOR DAY	*9*

REMARKS *71.8% - 4 hrs. firing on 3rd shift, 4 hrs. passing coal for sick coal passer.*

SIGNED *S. D. Port*

FIG. 7 FORM FOR DAILY BONUS STATEMENT TO FIREMEN

ination of the physical condition of equipment and apparatus is made. The result of this investigation is recorded on a form for cause of lost bonus, Fig. 6. This method is particularly valuable and outside of its direct advantages provides an additional and continuous training of the men in careful observation of harmful factors of the slightest nature.

36 Then by means of complete and trustworthy records the firemen are informed as to results of their work before they come back for the next watch, see Fig. 7, and moreover, while they are proceeding with their work, they have in addition to previously mentioned instruments indicating the condition of firing, continuous information as to results they are accomplishing up to any moment of their watch. This is accomplished by having coal weighing and water metering so balanced that an even number of dumps of feedwater

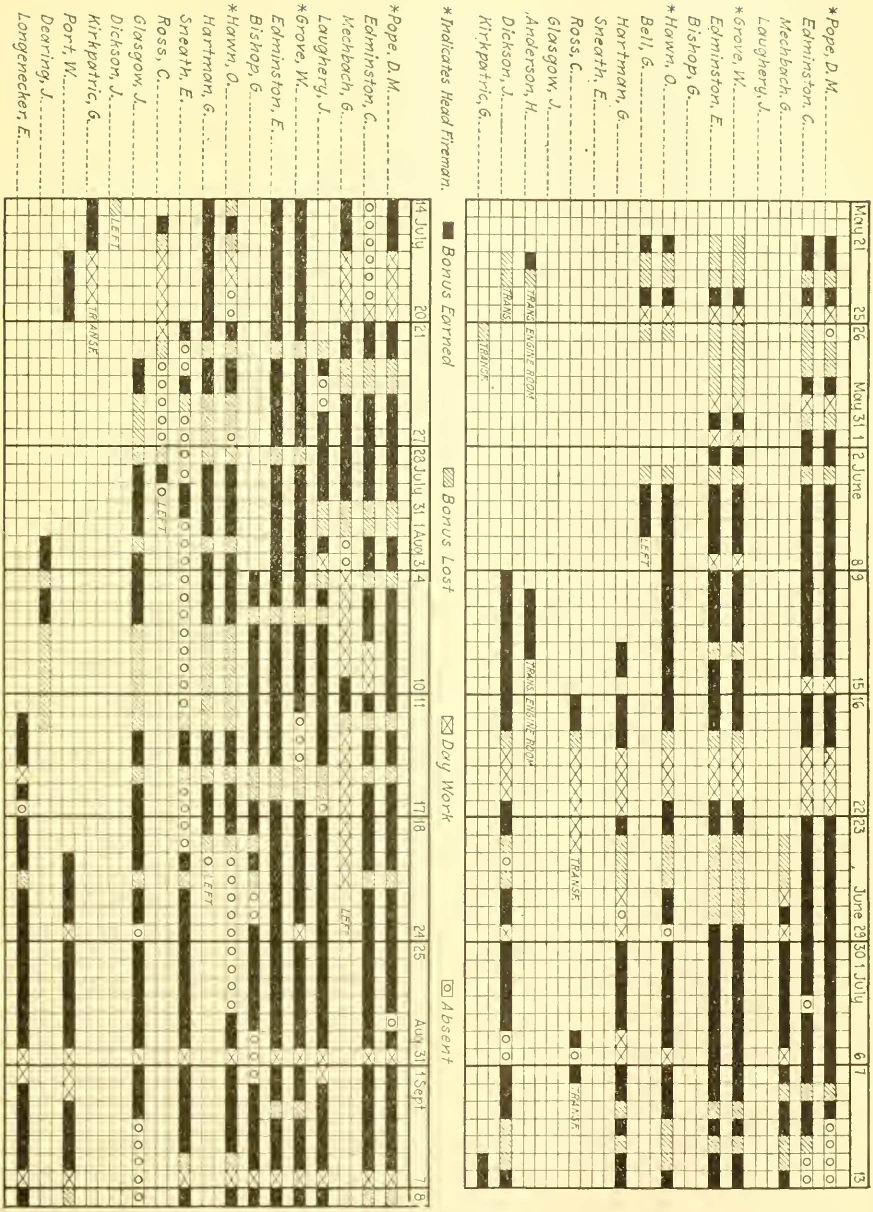


FIG. 8 FORM OF GRAPHICAL BONUS RECORD IN USE

and dumps of coal indicates that the ratio of evaporation (superheat, pressure and feed temperature being as specified), is on the safe side of the requirement.

37 The record of attainment of the task by firemen kept in the manner devised by H. L. Gantt, Fig. 8, offers such well-known advantages over any other method that it was adopted for general use by the above mentioned public utility companies. The illustration of this record, kept from the start of task work in the boiler house at Warrior Ridge of the Penn Central Light & Power Company, shows steady improvement and better habits of men. While the May record showed only 68.7 per cent efficiency of boiler and grates of the whole plant, the last month on this record showed the efficiency of 73.1 per cent. The number of day-men falling short on the task is steadily reducing. The number of men absent is, however, chiefly due to "days off" and summer vacations for the men work seven days a week in a plant of this character. It should here be stated that the departure from the principle of separate man's record made by the writer at first involuntarily proved to be so gratifying, creating as it did an unusually strong team spirit of coöperation, that the writer has never attempted to split the records of two or three men working jointly firing one battery of boilers.

38 The elements affecting the choice for or against task work are so numerous that they cannot all be mentioned. The essential thing is that some element of advantage to the workman be introduced sufficient to overcome actual or imaginary disadvantages believed by the men to exist as a result of the new state of affairs. This advantage takes the form of a sufficiently attractive and generous bonus to be paid for willingness to learn the new way and to continue to observe the instructions. Actual accomplishment of the task and consequent earning of the bonus means the adjustment of certain conditions concurrent with the adjustment of others. This adjustment being under the control of the employee is a physiological process principally depending on (*a*) the willpower of the man, and (*b*) physical fitness.

39 The man for whom a certain task is assigned must strive to accomplish its aim. The exercising of the power of will is a threefold process: first, the man must have a desire; secondly, he must make a choice of ways and means; and thirdly, he must perform necessary actions. The workman's desire from necessity is to earn his living at least; next he has to choose whether he shall work under instructions as set forth in the standing order and instruction cards for the

compensation offered; and lastly, he has to act according to his decision in order to satisfy his desire.

40 As a rule, the workmen feel that the adoption of a new method will impose an undue strain, but it is comparatively easy to overcome this misconception with the firemen from the fact that greater efficiency means less coal to be shoveled. On the other hand, the new conditions require the men to give their attention to instructions and the indications of the apparatus, which diverts them unpleasantly from chatting at leisure with their fellow workmen. This forms a more serious obstacle to their quick decision in favor of new routine than anything else.

41 Cases are not infrequent where the men, particularly those more or less in authority, take offense at scientific study and prefer to fight it or even quit rather than admit the advantages of the new practice. Temperament usually determines the vigor of the opposition. Social conditions occasionally influence a man's choice for or against the new regime. If a person who is admired by his associates happens to decide against task work, he is liable to influence the choice of his friends and acquaintances very materially. Members of labor unions are more apt to disfavor task work, while socialists are strongly in favor of it, feeling that the scientific method of management helps to solve the problem of nationalization of industries.

42 In order to determine the amount of bonus, there must be two limits established—a maximum and a minimum. The maximum bonus should be equal to the amount of net saving accomplished under given circumstances, while the minimum bonus is, of course, equal to zero. When the bonus to be paid actually reaches either of these limits it loses its usefulness since it loses its stimulating effect—with the management, if the maximum, and with the men, if the minimum. Since in an average boiler house the task results in about 25 per cent saving on the coal bill while the fireman's pay roll is from 10 to 15 per cent of the coal bill, it is evident that there is a considerable latitude for adjustment of bonus.

43 After the choice has been made in favor of task work, however, as a result of the stimulus offered, the third element, proper action, is yet far from being secured. To act in the chosen direction one must know how the desired result is to be accomplished. Lack of sufficient information necessarily produces a strong perception of uncertainty coincident with suffering. After the excellent essay on training workmen by Mr. H. L. Gantt, little if anything can be said

on this subject except, that in case of firemen, the success of attainment of the task is determined by detailed, patient, and prolonged training and instructions, and as such this is the most important function of the management. A dummy furnace was found to be an excellent means to break in the green hands.

44 Although the above requirements of additional compensation and exhaustive training for stimulating men's will to coöperate with the management in attainment of the state of high efficiency are imperative, they alone are insufficient. The psychical conditions

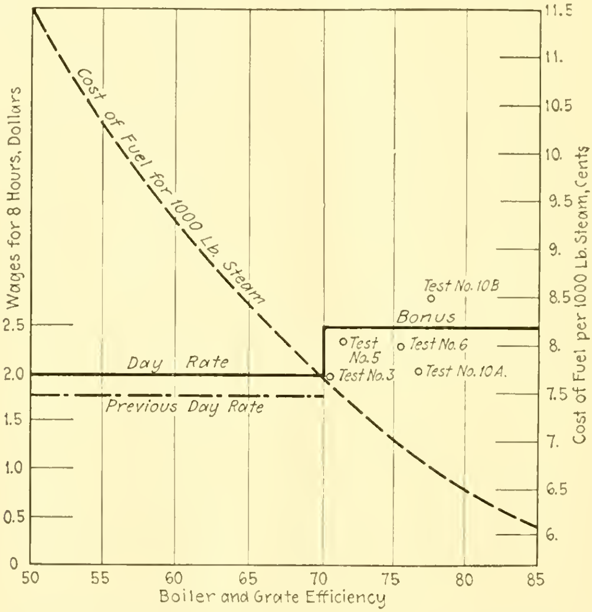


FIG. 9 DIAGRAM SHOWING METHOD OF TASK AND BONUS ADJUSTMENT

under which the men have to work must be so arranged as to insure the fullest preservation of their strength, health, and psychical faculties. The opposition exercised by some labor organizations in instances where greater efficiency is demanded from the workingmen without adequate safeguards to their vitality and ability to work is a just and well grounded fight against the short-sightedness of some self-termed efficiency experts.

45 In a boiler house the amount of work per man per hour is constant, and cannot be increased without knocking down the efficiency to a ridiculously low figure, but the number of foot-pounds of

work can be reduced in an inverse proportion to the increase of efficiency, so that the question of preservation of a man's health, etc., eliminates any consideration of overspeeding. The conditions which then remain for consideration are (*a*) temperature of room; (*b*) ventilation (dust and draft); (*c*) lighting; (*d*) drinking water; (*e*) restful seats; and (*f*) sanitary washrooms.

46 One familiar with the common layout of a power plant cannot over-emphasize the importance of the above conditions to enable the men to live up to their task day in and day out. While engine rooms not infrequently offer very pleasant and sanitary surroundings, boiler houses, the most important part of any plant, are so built as to make them unbearably cold in winter and uncomfortably hot during the summer; ventilation apparently serves either to fill the lungs with coal dust or to chill the perspiring men after cleaning their fires. Lighting is an unusual luxury, so that after looking into the furnace no man could read his gages or examine anything around the boiler. Good drinking water is rarely provided, and restful seats with backs (seats without backs are equal to no seat at all) were never found by the writer in any boiler house. Yet the mere fact that the firemen, if provided with seats having backs, can get through the cleaning of fires in 18 minutes per 100 sq. ft., while without them they consume at best 24 minutes, apparently should convince any unbiased mind.

47 On the contrary, the absence of an elementary condition of comfort in a working place where the men spend the better part of their lives is more harmful to the employers than to the employee. The petty annoyances and feelings of discomfort divert the attention of the men from the performance of their duty to means of avoiding the annoyance or harm. Steady attention on the part of the fireman is much more important than is generally realized. A psychological test conducted by the writer on the effect of the occasional drop of attention with the same individual and with individuals possessing different degrees of this faculty proved that *physical condition and strength being constant, the boiler efficiency percentage is in an almost direct proportion to the degree of attentiveness of the fireman.*

48 With healthy, sanitary and pleasant surroundings as a sufficient criterion for judging whether the man's task is harmful, a simple and apparently reliable method was devised by the writer. It is evidently beyond the means of ordinary time study to define whether or not the possible output in a unit of time is a safe one from the viewpoint of the preservation of the individual and the

nation. The problem in itself is twofold: (*a*) strain per unit of time in foot-pound per square inch of cross-section of a muscle, and (*b*) number of time units at work. As in every case where more than two variables are evolved the maxima are determined by the limiting conditions of variables, and the constant safe limit can be reached either by a comparatively great strain during a short time or a less

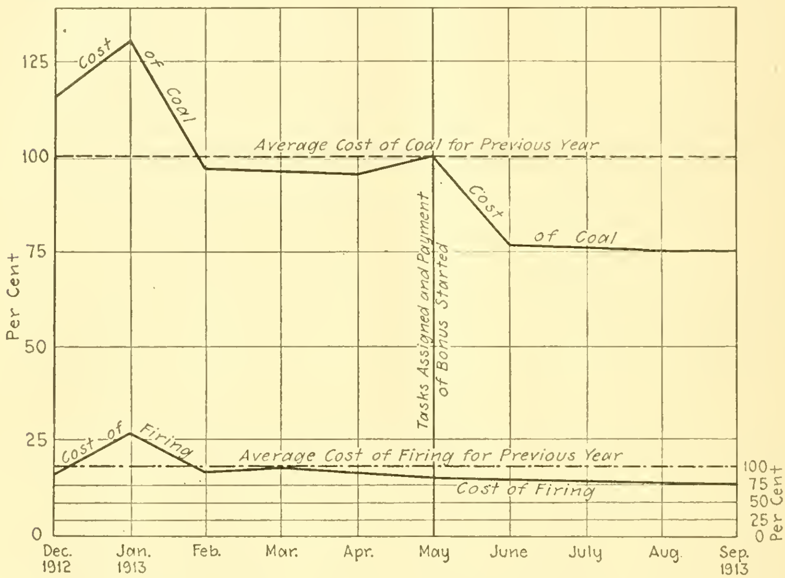


Fig. 10 Graphical Record of Actual Reduction of Cost of Coal and Labor per Kilowatt-Hour

intense strain during a longer period. If t and s are time and strain respectively, the equation

$$\frac{d}{d}\left(\frac{ct \times s}{t \times c's}\right) = 1,$$

if differentiated, illustrates the problem; yet, whether factor c for time or c' for strain has the same numerical value the experiments alone are able to show. More study along this line is needed.

49 In our experience we adopted in addition to time studies, a careful investigation of fatigue, both mental and physical, and measurements of the vitality of the men affected by various conditions of work and number of working hours per day. No task is reasonable unless the workman can fully regain his loss between quitting time and recommencing work the next day, and during a sufficiently

long period of observation a man should be able to gain or at least not lose anything in his vitality. Observations should cover at least four factors: (*a*) weight of body; (*b*) blood pressure; (*c*) temperature of body; and (*d*) pulse. The blood analysis while considered desirable is too cumbersome to make, and other indications being favorable can safely be omitted. Almost unanimous statements of those observing the task work performed in a great variety of industries assert that men are gaining in health and spirit, but scientifically definite data alone could prove this fact beyond any doubt.

50 Finally, the time element in relation to task setting for men,

DAILY POWER PLANT REPORT

PENN CENTRAL LIGHT AND POWER CO.
STATION Warrior Ridge

FOR 24 HOURS ENDING 9 (MONTH) 14 (DAY) '13 (YEAR) 7 .. (HOUR)

BOILER ROOM	WATCH 1	WATCH 2	WATCH 3	ENGINE ROOM	WATCH A	WATCH B	WATCH C
COAL USED (BANKING EXCLUDED)	48800	49200	34000	HYDRO ELECTRIC OUTPUT	980	850	30
WATER EVAPORATED	419800	408200	284000	STEAM GENERATED OUTPUT	21220	20450	15070
ACTUAL EVAPORATION	8.62	8.32	8.37	LOAD FACTOR	79.5	64.4	67.5
FACTOR OF EVAPORATION	1.2187	1.2185	1.2287	STEAM PER KWH	19.78	20.00	18.85
EQUIVALENT EVAPORATION	10.50	10.13	10.28	COAL PER KWH	2.30	2.40	2.26
EFFICIENCY OF GENERATION	73.4%	70.8%	71.8%	THERMAL EFF-CY OF PLANT	10.71	10.27	10.73
COST OF FUEL PER 1000 LBS OF STEAM	0.0815	0.0845	0.0833	COST OF FUEL PER KWH (INCLUDING BANKING)	0.00201	0.00204	0.00200

REMARKS:

COAL USED FOR BANKING 1 / " BOILERS DURING 6 / 9 HRS. 55 / 30 MIN. 3000 LBS. COAL ANALYSIS BTU AVE. B.T.U. 13900

TOTAL OUTPUT ________ KW HRS THE ABOVE IS A TRUE AND CORRECT SUMMARY OF RECORDS CHECKED BY ME S. D. Port SIGNED

Fig. 11 Example of Daily Report from the Plant showing Average Results

particularly if the work requires a considerable strain, must be settled by examination no less careful than the study of the time rate of driving boilers. When, however, as in the case of firemen, both physical strain and attention are required, it was found that with strong, healthy individuals the limiting factor on number of hours of profitable work is set not by physical exhaustion but by weariness of spirit. *Other conditions being equal, a fireman on a 12-hour watch is found to be about 4.5 per cent less efficient than the same man on an 8-hour shift.*

51 This time-limiting factor on human efficiency, taken in conjunction with a scientific certainty in determination of the most advantageous thermal efficiency, formed the grounds on which the

writer rejected the sliding scale of bonus rate results exceeding the task set by various degrees. The task set must be so little below the

DAILY POWER PLANT REPORT

PENN CENTRAL LIGHT AND POWER CO.
STATION Warrior Ridge

FOR 24 HOURS ENDING 9 (MONTH) 6 (DAY) '13 (YEAR) 7 A.M. (HOUR)

BOILER ROOM	WATCH 1	WATCH 2	WATCH 3	ENGINE ROOM	WATCH A	WATCH B	WATCH C
COAL USED (BANKING EXCLUDED)	52000	50000	31900	HYDRO ELECTRIC OUTPUT	1300	2240	60
WATER EVAPORATED	449000	430000	265500	STEAM GENERATED OUTPUT	22700	22560	14840
ACTUAL EVAPORATION	8.66	8.62	8.35	LOAD FACTOR	88.5	68.3	62.1
FACTOR OF EVAPORATION	1.2125	1.2159	1.2051	STEAM PER KWH	19.78	19.07	18.00
EQUIVALENT EVAPORATION	10.49	10.48	10.05	COAL PER KWH	2.29	2.21	2.15
EFFICIENCY OF GENERATION	73.9	73.8	70.8	THERMAL EFF-CY. OF PLANT	10.85	11.22	11.54
COST OF FUEL PER 1000 LBS OF STEAM	0.0823	0.0814	0.0848	COST OF FUEL PER KWH (INCLUDING BANKING)	0.00198	0.00189	0.00206

REMARKS:

COAL USED FOR BANKING 1 / " BOILERS DURING 6 / 8 HRS 55 / 40 MIN. 5000 LBS. COAL ANALYSIS BTU AVE. B. T. U. 13800

TOTAL OUTPUT ________ KW HRS THE ABOVE IS A TRUE AND CORRECT SUMMARY OF RECORDS CHECKED BY ME S. D. Port SIGNED

DAILY POWER PLANT REPORT

PENN CENTRAL LIGHT AND POWER CO.
STATION Warrior Ridge

FOR 24 HOURS ENDING 9 (MONTH) 7 (DAY) '13 (YEAR) 7 A.M. (HOUR)

BOILER ROOM	WATCH 1	WATCH 2	WATCH 3	ENGINE ROOM	WATCH A	WATCH B	WATCH C
COAL USED (BANKING EXCLUDED)	51850	54000	30750	HYDRO ELECTRIC OUTPUT	530	4890	
WATER EVAPORATED	436600	423000	260500	STEAM GENERATED OUTPUT	22470	22310	13400
ACTUAL EVAPORATION	8.43	7.85	8.50	LOAD FACTOR	78.3	74.4	55.8
FACTOR OF EVAPORATION	1.2125	1.2095	1.1965	STEAM PER KWH	19.43	18.99	19.46
EQUIVALENT EVAPORATION	10.22	9.49	10.17	COAL PER KWH	2.31	2.42	2.80
EFFICIENCY OF GENERATION	71.8%	66.7%	71.5%	THERMAL EFF-CY OF PLANT	10.72	10.26	10.80
COST OF FUEL PER 1000 LBS. OF STEAM	0.0837	0.0900	0.0840	COST OF FUEL PER KWH (INCLUDING BANKING)	0.00196	0.00205	0.00208

REMARKS:

COAL USED FOR BANKING 1 / " BOILERS DURING 7 / 8 HRS. 05 / 43 MIN. 2000 LBS COAL ANALYSIS BTU AVE. B. T. U. 13800

TOTAL OUTPUT ________ KW HRS. THE ABOVE IS A TRUE AND CORRECT SUMMARY OF RECORDS CHECKED BY ME S. D. Port SIGNED

FIG. 12 DAILY REPORTS SHOWING HIGH AND LOW AVERAGE RESULTS FROM THE PLANT

most advantageous point that it could be reached with greatest benefit to all concerned and it is not desirable from economical aspects either to fall short of or considerably to overreach it. Offer-

ing extra compensation for excess of the task requirement means in final analysis either that the investigator did not determine both limits, or that the management tempts a man to do more than the average employer dares to ask directly.

52 The example of efficient coöperation between employer and employee in the power plants of public utility corporations here referred to demonstrated the value of the above principles for setting task and accomplishing the predetermined results in firing boilers. The diagram in Fig. 10, showing cost per kilowatt-hour of fuel relative to firemen's payroll and bonus before and after adoption of scientific basis for firing, presents, outside of the interesting reduction in cost since the change of method took place, another feature also of no less importance, namely, that since that time the unit cost remained practically constant, while previously it fluctuated considerably. Samples of daily power plant reports are shown in Figs. 11 and 12.

53 The writer does not claim to have made any new discovery or exhaustive treatment of the technique of the question. The undertaking of presenting to the profession a brief outline of systematic method of task setting for one particular job can be considered fairly fulfilled, if the necessity of thorough scientific research and accumulation of available data for further enlightenment of the many still obscure facts and their coördinations is sufficiently demonstrated.

APPENDIX NO. 1

54 The diagrams in Figs. 13 and 14 represent applications of the Grinevetski method of graphical analysis of the working process in a steam boiler. Briefly stated, the diagrams consist of two main curves: a heat curve TQ and a characteristic HQ, a third auxiliary curve, known as a radiation curve, being added for use in determining the influence of radiation of the incandescent fuel on the grate on the whole process. The heat curve is constructed from the temperatures of gases T as ordinates and the heat in the gases of corresponding temperature as abscissa Q. The heat developed during the combustion could be represented as a function of temperature. Assuming the following symbols:

B_h = Fuel consumed per hour in lb.
G_b = Weight of gases in lb. per 1 lb. of fuel burned
C_p = Average specific heat of gases (at p = const.)
T = Temperature of gases
T_b = Temperature of furnace
T_e = Temperature of escaping gases
T_a = Temperature of air entering the furnace
Q' = Heat in gases in B.t.u. at temperature T
Q_a = Heat in gases in B.t.u. at temperature T_a
Q = Heat of gases developed during combustion in B.t.u. per hour
Q_b = Heat value of fuel in B.t.u. per lb.

thus

$$Q = Q' - Q_a \qquad [1]$$

and

$$Q' = cG_bB_ht \qquad [2]$$

The specific heat of the gases could be represented as a lineal function of temperature

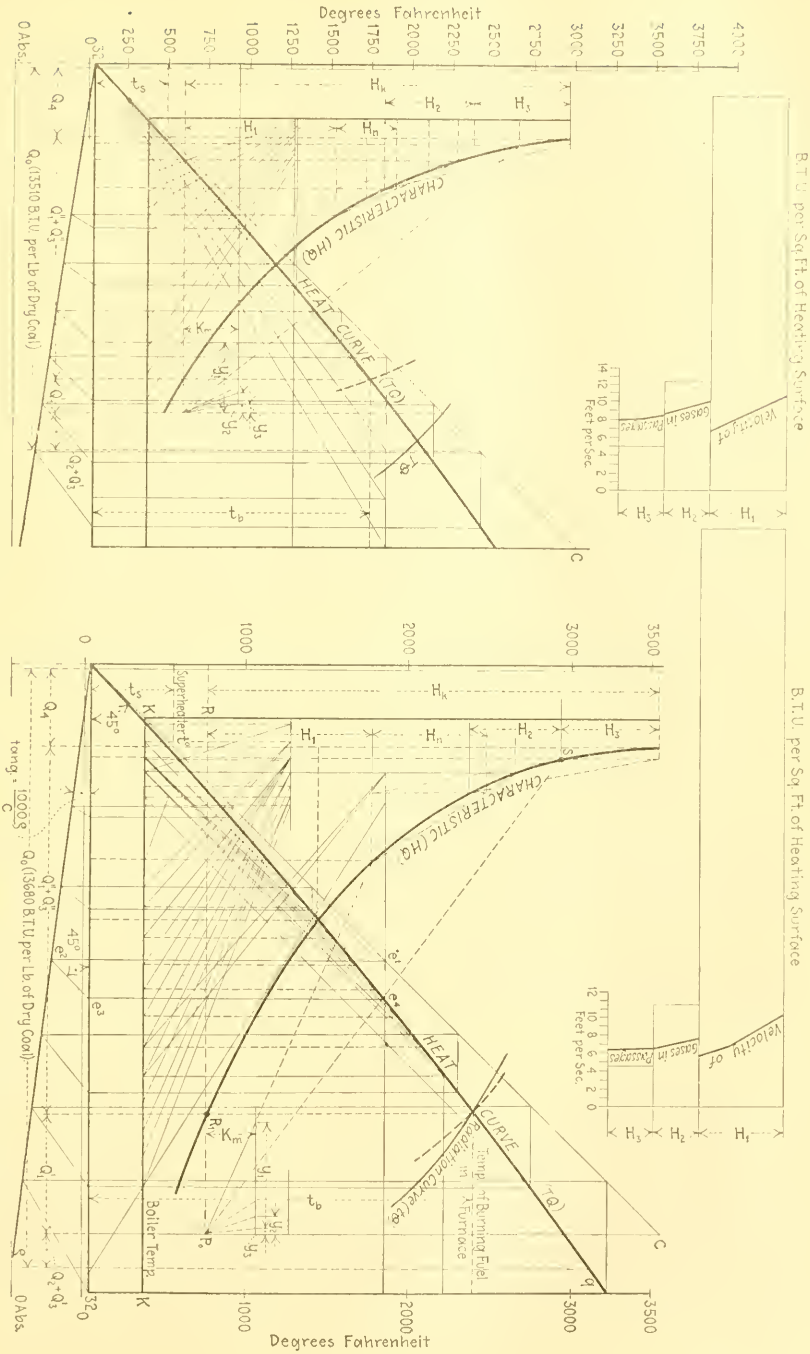
$$C_p = c + \delta t \qquad [3]$$

where c and δ are constant for the fuel of given composition and definite percentage of CO_2 in gases. For variable CO_2 and different fuels, c and δ vary but slightly and for all practical use have little effect on the calculation.

55 Thus from equations [2] and [3] we have

$$Q' = cG_bB_h\left(t + \frac{\delta}{c}t^2\right) \qquad [4]$$

In this cG_bB_h is constant, except in case of infiltration of air into gas passages, and at any given condition of combustion can be taken as a scale for the diagram. The expression $\left(t + \frac{\delta}{c}t^2\right)$ is an equation of a parabola, and as such can be easily plotted. Assuming C, in inches, is a scale for ordinate equal to 1 deg. fahr. and W, in inches, is a scale for abscissa equal to 1 B.t.u., equation [4] becomes:



FIGS. 13 AND 14 DIAGRAMS INDICATING METHOD OF ANALYSIS OF THE WORKING PROCESS IN STEAM BOILERS

$$Q'w = \left(t + \frac{\delta}{c} t^2\right) b \text{ .... [5]}$$

and the method of plotting this curve is evident. It gives the heat curve TQ. If $Q' = Q_a$; then $Q = 0$; and therefore the ordinate shall pass through temperature T_a of the curve.

56 From equations [4] and [5]

$$w = \frac{C}{cG_b B_h} \text{ in inches........................ [6]}$$

Referring the fuel consumption per hour to a unity when $B_h = 1$ lb., equation 6a is obtained

$$w_o = \frac{C}{cG_b} \text{ in inches........................ [6a]}$$

57 The application of this heat curve is apparent. The temperature of the gases T is known and, being represented in a scale b, if referred to the curve and projected on abscissa, gives the corresponding heat in the scale $w = 1$ B.t.u. Thus from the heat value of the fuel and the weight of the gases developed from its combustion, may be found the theoretical temperature in the furnace T'_b by projecting on the curve $Q_b w_o$ and reading the temperature at this level on the corresponding scale of ordinates.

58 The deviation of the parabola from the straight line OC indicates the variation of specific heat of gases with the change of temperature, which is considerable at the high temperatures. If

$Q_o = B_h Q_b$ = heat available

$Q_1 = Q'_1 + Q''_1$ = heat utilized $\begin{cases} Q'_1 \text{ by radiation} \\ Q''_1 \text{ by convection and transmission} \end{cases}$

Q_2 = the loss due to incomplete combustion

$Q_3 = Q'_3 + Q''_3$ = external losses $\begin{cases} Q'_3 \text{ in furnace} \\ Q''_3 \text{ in gas passages} \end{cases}$

Q_4 = is the heat lost in escaping gases.

We can study graphically the heat balance as well as ascertain and locate the cause of any loss due to inefficient performance of a certain part of the boiler or furnace. Q_4 is directly shown by the heat curve, and an evaporative test supplies the data of Q_1; hence the equation of heat balance is:

$$Q_2 + Q_3 = Q_o - (Q_1 + Q_4) \text{ .... [7]}$$

Similarly by further graphical analysis the other elements could be ascertained.

59 It is useful to plot also the curve of radiation $T\theta$ which represents the equation

$$\theta = \left\{\frac{T + 459.2}{491.2}\right\}^4$$

In accordance with the equation of Stephen for an ideal black body, the heat transmitted by radiation is:

$$Q = \sigma F T^4$$

where T = absolute temperature of the body, F = radiant area, σ = constant. This constant in metric units for lamp black $\sigma_1 = 4.33$ cal per m² per hr., or 1.678 B.t.u. per sq. ft. per hr. Professor Grinevetski gives a table (see Table 1) for θ at temperatures from 302 deg. fahr. to 2912 deg. fahr. The intersection of the radiation curve, plotted in accordance with this method, with the heat curve

TABLE 1 VALUES OF θ AT VARIOUS TEMPERATURES *

T, Deg. Cent.	θ	T, Deg. Cent.	θ
150	320	900	18,930
200	501	950	22,370
250	748	1000	26,540
300	1078	1050	30,650
350	1506	1100	35,550
400	2051	1150	41,000
450	2732	1200	47,080
500	3571	1250	53,800
550	4590	1300	61,210
600	5810	1350	69,370
650	7260	1400	78,340
700	8960	1450	88,150
750	10,955	1500	98,810
800	13,210	1550	110,460
850	15,980	1600	122,800

* Values calculated in c. g. s. units.

determines T_b, the temperature in the furnace and Q'_1, the heat utilized by radiation. In this case, like in all others, the comparison of ideal conditions with those observed gives a valuable indication as to what direction we must apply our efforts, and in most cases as well supplies us with the means of measurement. Only the analysis of the whole problem in its entirety, however, can tell whether further efforts are worth trying in practice or not.

60 The rule made manifest in this research on radiation could be expressed as follows: Under equal conditions of combustion, the temperature of the furnace is in direct proportion to the rate of firing

$$B_h = \frac{\text{lb. of fuel per hour}}{\text{area of grate surface}}$$

and in inverse proportion with the intensity of radiation.

61 The second main curve, or characteristic, has the same heat scale on abscissa as the heat curve, but as ordinates we take the area of heating surface, H. If

k = factor of heat transmission in B.t.u. per sq. ft. per hr., and

T_k = temperature of boiler water in accordance with Redtenbacher's researches, we have

$$k(t-t_k)dH = -dQ$$

whence

$$\frac{dQ}{dH} = k(t-t_k) \qquad [8]$$

62 This equation can be plotted very conveniently, if k is constant, and the tangent of the angle ϕ, between tangent to characteristic curve and the line of ordinates, is in direct proportion to the difference of the temperature of the water in the boiler and the temperature of the gases in contact with a given section of the heating surface. Thus, with T_k and k known, the shape of the characteristic curve is determined by the temperature of gases (abscissa Q) and is independent of the ordinate. This is a particularly convenient peculiarity,

since the curve can be plotted from any initial temperature without changing its shape; a number of tangents plotted in accordance with equation [8] determines the curve. From this equation it is evident, that with the decrease of $(t-t_k)$, tang ϕ decreases and with $t=t_k$, tang $\phi=0$, and our ordinate KH of the heat curve for temperature tk will be the asymptote to the characteristic curve. If with $t=t_k$, $H=0$, and the abscissa of the characteristic curve will be on the ordinate T_b of the heat curve scale. The ordinate of the characteristic curve starts from the axis thus located, $R-R$, which determines the area of heating surface in contact with the hot gases, while the corresponding temperature of gases is represented by the distances between OQ and tQ. The scale for the heating surface area is determined as follows:

$$f=\frac{nk}{cG_bB_h}\text{ in inches} \qquad [9]$$

63 From this we can estimate the temperature of the gases in any part of the gas passages. If $H=H_k$ (total heating surface), we know from the heat curve that $T=T_s$ and Q_4. On the other hand, if we know the various temperatures, we can locate the sections of gas passages in which they are present and from the characteristic, the areas of the heating surface. If k (factor of heat transmission) is unknown, but T_b and T_s are known, the factor of heat transmission itself can be determined from equation [8].

64 The rate of driving the heating surface is shown by the characteristic curve. Assume

$$g=\frac{dQ}{dH}$$

for average conditions and

$$g_m=\frac{Q'-Q''}{H''-H'}$$

for the local rate of driving in B.t.u. per sq. ft. per hr. Also

$$g_m=\frac{Q'-Q''}{H''-H'}$$

which equals average rate of driving for a given portion of a heating surface.

65 The first equation is a tangent of the angle between a line tangent to the characteristic curve and the axis of ordinates, and the second, a tangent of an angle between a line normal to the same ordinate and $(H''-H')$, or

$$\text{tang }\phi=\frac{dQw}{dHf} \qquad [10]$$

Since

$$w=\frac{b}{cG_bB_h}$$

and

$$f=\frac{nK}{cG_bB_h} \qquad [9]$$

the equation becomes

$$g=\text{tang }\phi\times\frac{nk}{b} \qquad [11]$$

This can be plotted as

$$g=\frac{y}{h} \qquad [12]$$

where from $h=\frac{b}{n}$ is a scale for the rate of driving the heating surface = 1 B.t.u per sq. ft. per hr. From equation [12] can be determined g_m for the entire boiler and furnace in which case Q'_1 should be added as radiant heat absorbed.

66 In determining the volume of gases, the volume V with p = constant is proportionate to the absolute temperature and evidently can be read on the ordinates of the heat curve where the scale for volumes per second in cu. ft. will be

$$V\zeta = \frac{1670\, h_b b}{(g_b - 1) B_h \zeta} \quad \text{[13]}$$

where

h_b = barometric pressure

ζ = ratio of volumes of gas and air at the same temperature.

67 Thus, if $h_b = 760$ mm,

$$V\zeta = \frac{1{,}260{,}000\, b}{(g_b - 1) B_h \zeta} \quad \text{[13a]}$$

Whence from equations [13 and 13a], we learn the scale for volumes of gases per second, we can determine the volumes per second for any temperature at any portion of gas passages. Consequently taking into consideration the cross-sectional area of gas passage, we can determine the average velocity of gases in the corresponding places.

APPENDIX NO. 2

DIRECTIONS FOR USE OF POWER PLANT LOG CALCULATOR

Weight of Feedwater. Set 10B (inner scale) opposite the Wilcox water meter reading found on the dial. The result in pounds appears on the dial opposite the feed temperature marked on the disk.

Cubic Feet into Gallons. Set 10B opposite the number of cubic feet on the dial. The result in pounds appears on the dial opposite the observed temperature.

Steam Consumption per Kilowatt-Hour or Horsepower-Hour. Set the kilowatts or horsepowers of output on the disk opposite the number of pounds of steam consumed, read on the dial. The result in pounds per kilowatt or horsepower-hour appears on the dial opposite 10B of the disk.

Fuel per Unit of Output. Same method as above.

Actual Evaporation. Set the number of pounds of fuel, read on disk, opposite the number of pounds of water evaporated, on the dial. The result appears on the dial over 10B of the disk.

Factor of Evaporation. Find feedwater temperature at the left of the diagram in the center of the chart and follow the horizontal line to its intersection with the diagonal line representing gage pressure; then follow the vertical line down and read the factor of evaporation at the bottom.

Equivalent Evaporation. Set 10B of the disk opposite the factor of evaporation number on the dial. The result appears on the dial opposite the actual evaporation number on the disk.

Efficiency of Boiler and Grate. Set the heat-value factor (B.t.u. per pound of fuel) shown on the disk opposite 10A on the dial. The result appears on the dial opposite the equivalent evaporation number on the disk.

Cost of 1000 Lb. of Equivalent Steam. Set the observed efficiency number on the disk opposite the cost of 1,000,000 B.t.u. in the shape of fuel shown on the outer scale of the dial (which is designated for calculation of cost, but does not show the cost). The result appears in cents on the dial opposite 10B.

Load Factor. Set the number of kilowatts in the peak power load on the disk opposite the number of average power read on the dial. The result appears on the dial opposite 10B.

Thermal Efficiency of the Whole Plant. Set 10B of the disk opposite the constant for kilowatts or horsepower printed on dial. Note the point on the dial opposite the output number on the disk. Set the disk's figure of pounds of fuel consumed under previously located point on dial opposite 10B. Set again the disk so that opposite the point thus found will be the number of B.t.u. per pound of fuel used. Do not use constants for the determination of boiler efficiency. The result appears on the dial opposite the 10B mark.

Use as Slide Rule. Any multiplication can be made by following the rule for determination of equivalent evaporation, and division by following the rule for load factor. All these calculations and others not mentioned can be made quickly and accurately with the calculator.

APPENDIX NO. 3

DIMENSIONS AND PROPORTIONS OF WATER TUBE BOILERS, WARRIOR RIDGE, PA.

Rated horsepower	600
Tubes	
15 rows, 20 tubes each, total	300
Diameter, in.	4
Circumference, in.	12.566
Length, ft.	18
Area of one tube, sq. in.	2,714.25
Total tube area, sq. in.	814,276.8
sq. ft.	5,634.7
Legs	
13 ft. x 8.5 ft. x 2 ft.	221.0
Tube holes (2 x 300 x 12.566), sq. ft.	59.4
Actual heating surface of legs (221.0 − 59.4), sq. ft.	161.4
Lower part of drums, sq. ft.	180.4
Effective water heating surface, sq. ft.	59,967
Shaking Grates	
Width of grate, ft.–in.	13–1
Depth of grate, ft.–in.	7–6
Area of grate, sq. ft.	100
Number of air slots in sections	21
Size of slots, in.	5 x 1.75
Air space in each section	
Slots, sq. ft.	0.260
Around section, sq. ft.	0.90
Total, sq. ft.	0.350
Proportion of water heating surface to grate area	58.2:1
Air space to grate area, per cent	35
Proportion of flue area to grate area	0.23:1
Ratio of grate surface to flue area	4.35:1
Area of 4 ash pit doors, sq. ft.	40.42
Area of uptake, sq. ft.	23
Dead space in tubes, per cent	42
Brick Lined Chimney (common for 4 boilers)	
Height from base, ft.	207
Height from grate, ft.	200
Smallest diameter top, ft.	10
Smallest area, sq. ft.	28.5

TABLE 2 DATA AND RESULTS OF EVAPORATIVE TRIALS

On Battery of 2 Water Tube, Edge Moore Boilers, Hand Fired, at Warrior Ridge Plant of the Penn Central Light and Power Company.

		Test No. 1 Average for 80 Days	Test No. 2 13 Hours	Test No. 5 14 Hours	Test No. 3 12 Hours	Test No. 6 10 Hours	Test No. 10A 6 Hours	Test No. 10B 8 Hours	Test No. 8 10 Hours
	Average Pressures								
11	Steam pressure by gage, lb. per sq. in.	173.7	173.3	162.0	163.3	165.0	168.0	165.0	160.0
12	Force of draft between damper and boiler, in. water	0.85	0.70	0.55	0.58	0.50	0.64	0.62	0.71
13	Force of draft in furnace, in. water	0.45	0.34	0.32	0.35	0.30	0.26	0.5	0.35
14	Force of draft in ash-pit, in. water	0.09	0.18	0.07	0.11	0.08	0.05	0.04	0.08
14a	Velocity of air through ash-pit doors, ft. per min.	*	*	588.0	*	533.0	637.0	550.0	655.0
	Average Temperatures								
15	External air, deg. fahr.	37.8	47.4	32.0	46.2	42.0	43.0	33.0	28.0
16	Fire room, deg. fahr.	54.0	62.6	53.5	63.2	61.0	45.0	45.0	44.0
17	Steam, deg. fahr.	479.6	486.0	508.0	477.0	514.3	535.0	532.0	497.5
18	Feedwater entering heater, deg. fahr.	68.0	71.0	57.0	66.0	62.0	....	....	....
20	Feedwater entering boiler, deg. fahr.	167.5	168.0	153.7	154.3	166.5	123.6	122.5	141.6
21	Escaping gases from boiler, deg. fahr.	575.0	495.0	590.0	535.0	570.0	650.0	660.0	....
	Fuel								
23	Size and condition	R of M Broad Top	R of M Broad Top	R of M, Bitum. Broad Top	R of M Broad Top	R of M, very wet Broad Top	R of M, clean, from Broad Top East	Mixed. weathered, Broad Top and Moshan	R of M, semi-Bitum., Clearfield
25	Weight of coal as fired, lb.	27793.0	38339.0	54330.0	36379.0	35850.0	25250.0	29750.0	44750.0
26	Moisture in load, per cent	1.5	2.0	2.3	1.6	3.1	2.9	2.2	4.4
27	Total weight of dry coal consumed, lb.	27382.3	37572.2	53080.0	35797.0	34739.0	24720.0	29095.0	42780.0
28	Total ash and refuse, lb.	3850.0	5640.0	6475.0	4589.0	5385.0	2521.0	4226.0	5134.0
29	Quality of ash and refuse	white ash	loose	gray	clinkers	....	loose clinkers	fused clinkers	fused clinkers
30	Total of combustible consumed, lb.	23532.3	31.932.0	46605.0	31108.0	29454.0	22200.0	24869.0	37646.0
31	Ash and refuse to dry coal, per cent	14.5	15.0	12.2	13.1	15.5	10.2	15.2	12.0

* No Anemometer available

	APPROXIMATE ANALYSIS OF COAL											
32	Fixed carbon, per cent	75.1	74.4	78.0	77.1	75.9	77.0		71.6	69.6	70.7	
33	Volatile matter, per cent	12.2	12.3	12.1	12.4	12.2	14.2		16.5	14.5	19.1	
35	Ash, per cent	12.7	13.3	9.9	10.5	11.9	8.8		11.9	15.9	10.2	
	Total on dry basis	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0	100.0	
34	Moisture, per cent	1.5	1.5	2.2	1.6	1.9	1.5		1 2	1.5	4.3	
36	Sulphur separately determined	....	....	....	....	....	....		....		...	
	CALORIFIC VALUE OF FUEL											
50	Calorific value of oxygen calorimeter per lb. dry B.t.u.	13786	13510	14233	13800	13680	14395		13594		14221	
51	Calorific value per lb. of combustible B.t.u.	15791	15590	15640	15420	15527	15874		15770		15836	
							Analyses				Analyses	
	ANALYSIS OF ASH AND REFUSE						Ash	Clinker			Ash	Clinker
44	Carbon (computed), per cent	27.2	43.0	17.7	20.2	21.0	21.8	6.2	....		23.7	5.1
45	Earthy matter (computed), per cent	72.8	57.0	82.3	79.8	79.0	78.2	93.8	....		76.3	94.9
	FUEL PER HOUR FOR BOILER											
46	Dry coal consumed per hour, lb.	1956.0	1445.1	1900.0	1493.05	1737.0	2060.0		1818.5		2139.0	
47	Combustible consumed per hour, lb.	1707.5	1249.0	1664.0	1296.0	1472.0	1800.0		1575.0		1921.0	
48	Dry coal consumed per sq. ft. of grate surface per hr.	19.56	14.45	19.0	14.93	17.37	20.6		18.2		21.39	
49	Combustible per sq. ft water heating surface	0.29	0.21	0.28	0.223	0.25	0.31		0.27		0.33	
49a	Wet coal per kw-hr., lb.	2.87	2.65	2.47	2.25	2.27	2.012		2.106		2.10	
49b	Air per lb. of combustible, lb.	....	....	17.1	....	17.5	17.1		16.9		16.6	
	QUALITY OF STEAM											
55	Superheat, deg. fahr.	102.9	109.7	136.1	104.8	141.3	160.5		159.0		126.5	
56	Quality of steam (C. E. E.)	1.043	1.047	....	1.044	....	1.069		1.069		1.056	
56a	Quality of steam (G. H. Barrus)	....	....	1.076	1.059	1.079	1.0906		1.090		1.071	
	WATER											
57	Total weight of water fed to boilers, lb.	171,552	293,537	440,587	309,472	291,783	213,733		234,061		341,684	
58	Equivalent water fed from and at 212 deg. fahr., lb.	198,303	339,329	523,461	361,340	343,808	262,977		291,755		406,672	
59	Water actually evaporated, corrected for quality of steam, lb.	178,929	307,333	469,667	327,730	314,834	233,097		255,126		365,943	
60	Factor evaporation	1.156	1.156	1.1881	1.1676	1.1783	1.2304		1.2294		1.1902	
61	Equivalent water evaporated into dry steam from and at 212 deg. fahr., lb.	206,830	355,277	563,244	382,659	370,969	285,803		318,013		435,546	

TABLE 2—*Continued*

	Test No. 1 Average for 80 Days	Test No. 2 13 Hours	Test No. 5 14 Hours	Test No. 3 12 Hours	Test No. 6 10 Hours	Test No. 10A 6 Hours	Test No. 10B 8 Hours	Test No. 8 10 Hours
WATER PER HOUR–BOILER								
62 Water evaporated corrected for quality, lb.	12,780	11,821	16,774	13,655	15,741	19,425	15,945	18,297
63 Equivalent evaporation, lb.	14,774	13,665	20,116	15,710	18,548	23,817	19,876	21,777
64 Equivalent evaporation per sq. ft. of water heating surface, lb.	2.54	2.34	3.45	2.701	3.19	4.09	3.41	3.74
64a B.t.u. absorbed per sq. ft. water heating surface	3161.5	2912.6	3357.6	3393.8	3096.8	....	....	3629.0
HORSEPOWER								
65 Horsepower developed	428.2	396.07	583.1	455.3	537.6	693.3	547.1	631.2
66 Builders rated, h.p.	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0
67 Percentage of builders' h.p. developed	71.4	66.5	97.02	75.9	89.6	115.5	91.2	105.2
ECONOMIC RESULTS								
68 Water apparently evaporated per lb. coal as fired, lb.	6.17	7.65	8.109	8.507	8.139	8.47	7.867	7.635
69 Equivalent evaporation per lb. of coal as fired, lb.	7.44	9.26	10.367	10.52	10.349	11.319	10.689	9.733
70 Equivalent evaporation per lb. of dry coal, lb.	7.55	9.46	10.611	10.66	10.678	11.521	10.930	10.181
71 Equivalent evaporation per lb. of combustible, lb.	8.79	11.12	12.085	12.301	12.594	12.874	12.78	11.569
EFFICIENCY								
72 Efficiency of boiler, per cent.	54.02	69.21	74.98	77.412	78.78	78.70	78.64	70.261
73 Efficiency of boiler and grate, per cent.	52.37	67.94	72.35	75.00	76.03	77.667	78.023	69.479
73a Efficiency of gasification of fuel in furnace, per cent.	98.51	99.8	96.5	96.9	96.5	98.6	99.02	98.8
COST OF EVAPORATION								
74 Cost of coal per ton of 2240 lb. delivered to coal pockets	$2.15	2.15	1.85	1.85	1.85	1.85	1.895	1.94
74a Cost of coal per lb. delivered to coal pockets	$0.00096	0.00096	0.000826	0.000826	0.000826	0.000826	0.000826	0.000866
74b Cost of 1,000,000 B.t.u. in shape of coal	$0.07	0.071	....	....	....	0.057	0.0622	0.0609
75 Cost of evaporating 1000 lb. of water under observed conditions	$0.155	0.125	0.1018	0.0968	0.1014	0.0975	0.105	0.1134
76 Cost of fuel for evaporating 1000 lb. of water from and at 212 deg fahr. (corrected for quality of steam)	$0.1291	0.1036	0.0796	0.0785	0.0798	0.0729	0.0772	0.0889
				0.0741	....	0.065	0.0719	0.0831

	Smoke Observations and Firing								
77	Smoke as observed, per cent	30	15	1	0	1	0	not observed	5
80	Kind of firing	Coking	Spreading	Spreading	Spreading	Spreading	Spreading	Spreading	Spreading
81	Average thickness of fire, in.	16	12	10	6	7	8	7	8
82	Average intervals between firings for each boiler, min.	22	15	15	8	7	8	10	10
83	Average time between times of leveling or breaking up, min.	....	....	....	....	....	60	60	45
	Analysis of Dry Gases								
84	Carbon dioxide, CO_2, percentage by volume	4.3	6.9	11.77	Orsat apparatus out of order, one reading CO_2 12.5 per cent	11.26	12.1	12.2	9.5
85	Oxygen, O, percentage by volume	13.0	13.1	8 11		7.56	7.7	6.2	10.2
86	Carbon monoxide, CO, percentage by volume	0.6	0.3	0.01		0.11	0.1	0.2	0.1
88	Nitrogen, N, percentage by volume	79.0	79.0	80.11		....	80.1	81.4	80.2
89	Hydrocarbons, HC, percentage by volume	4.1	0.7	1.11		2.07	1.1	2.4	1.2

Remark: Heating surface (water) as accepted in these computations does not include surface of steam drums and superheater tubes.

FOREIGN REVIEW

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

With this number the second year of the Foreign Review is concluded.

THIS MONTH'S ARTICLES

Now that purchase of coal by heat unit is gaining in popularity, the article by Dosch on taking coal samples for calorimetric tests and exact heat value determination is particularly timely, in that it recommends to supplement the usual calorimetric determination by a determination of non-combustible constituents of the coal, and, in the case of boiler tests, also by a test of ash. In the section of Hydraulics the exposition of the theory of Allievi on the phenomena of water-hammer is continued. A graphical method for the consideration of conduit characteristics is given, and the interesting fact is established that entirely dissimilar conduits may be represented by the same pair of characteristic parameters. The distinction between constructional and functional characteristics of a conduit is established, and it is shown that a change in one of the functional characteristics produces, with respect to water-hammer phenomena, practically a new conduit. The second part of the work of Allievi will be reported as soon as the publication of the text used as the original is concluded.

The article of Dumanois on Diesel Engines as applied for the propulsion of battleships brings out some of the difficulties with which the designer of the large Diesel engine has to contend, viz., excessive transient pressures and excessive temperatures in the cylinder, the latter, unless special precautions are taken, is apt to reach so high a limit as to cause the decomposition of the lubricant and consequent disturbances in the operation of the engine. The author also calls attention to the difficulties due to the rise, in large engines, of excessive stresses. In the same section is described an interesting modification of the Oechelhauser oil engine, with its highly efficient system of scavenging and economical use of compressed air. Attention is called to the German regulations on the use of liquid fuel locomotives underground, the strict enforcement of which would certainly help to prevent accidents due, e. g., to

careless use of an inflammable fuel under conditions where fire and explosions are particularly dangerous.

Two constructions are described with aerial screw propulsion on land and water, which may be of particular interest in the North where an efficient system of mechanical propulsion over snow is desirable. The next abstract, on mechanical models and methods of demonstrating mechanical law, may be of interest to teachers of mechanics. In the same section A. Lechner shows how certain problems of torsion may be solved graphically, and, in particular, how the distribution of shear-stresses in a cross-section may be determined.

Several interesting new constructions are described in the section Steam Engineering, such as the R. Wolf superheated steam compound locomobile, the Ferranti pressure-regulating valve, the new 2C type fast train superheated steam four-cylinder Prussian locomotive, etc. There will also be found data on power consumption in air liquefaction, dynamic stresses in steam turbine blading, discussion on the importance of notch shock tests, graphical differentiation, etc.

ABSTRACTS OF ARTICLES

Alloys

Autogenous Welding of Copper and Copper Alloys (*Autogene Schweissung von Kupfer und Kupferlegierungen. Acetylen*, vol. 16, no. 18, second section, p. 173, serial article. *p*). Contains a detailed list of copper alloys, giving trade names and chemical composition of various bronzes, brasses, bearing metals, bell metals, etc.

Fuels

Influence of Non-Combustible Matter in Coal on Taking Samples and Exactness of Heat Value Determinations (*Einfluss des Unverbrennlichen der Kohle auf die Probeentnahme und die Genauigkeit der Heizwertbestimmung*, A. Dosch. *Braunkohle*, vol. 12, no. 31, p. 531, October 31, 1913. 5 pp., 2 tables. *ep*). The author expresses a doubt as to whether a sample used for calorimetric tests really gives a fair knowledge of the heat value of the large masses of the coal used, e. g. in evaporation tests of a boiler. To determine this he recommends an additional determination of the percentage of noncombustible matter in the coal sample, and also in the ash after the test, such recommendation being based on the supposition that the more uniform the constitution of the coal, the more the calorimetric test data approach the actual heat value. This method would have been very simple, if, on the one hand, the residues of combustion consisted of incombustible matter exclusively, and if, on the other hand, none of this matter were carried out of the smoke-stack by the draft. The amount of combustible matter present in the residues of combustion can be determined without much trouble and with fair exactness by direct analysis, while the amount of noncombustible matter carried up the flue can be in most cases only estimated. The author presents a tentative arithmetical method for calculating the actual heat value of a fuel from the calorimetric data and amount and constitution of ash in the calorimeter and on the grate.

Hydraulics

Theory of the Water Hammer (*Théorie du coup de bélier*, L. Alliévi. *Bulletin technique de la Suisse Romande*, vol. 39, nos. 11, 14, 15, pp. 121, 159, 171, June 10, July 25, August 10, 1913. Serial article, not finished. *tA*). Continuation of the abstracts published in *The Journal*, August 1913, p. 1287, September 1913, p. 1434, and November 1913, p. 1685. The systems of values characterizing the conduit may be represented graphically by means of a linear abacus. Since $\rho = \dfrac{av_o}{2gy_o}$, it may be represented as a function of v_o, in a system of rectangular coördinates (Fig. 1A) by a straight line passing through the origin; the angular coefficient of this line will depend on the magnitudes of y_o and a, or, in the final count, on the load y_o, so that the complete system of ρ, for all

possible conduits, i. e. for all y_o possible, and for all normal velocities v_o permissible, will be represented by a bundle of rays (Fig. 1A) starting from the origin of the axes ρ and v_o. If, however, the thickness of the walls of the conduit is determined, as is usually the case, by the magnitude of the static load y_o, the velocity of propagation of variations a is a function of y_o, so that the entire system of conduits represented by the two parameters ρ and ϑ is reduced to only a double infinity. It is important to understand very clearly that under this triple (or double as the case may be) infinity of conduits, characterized by the two elements ρ and ϑ, are really grouped conduits quite different from one an-

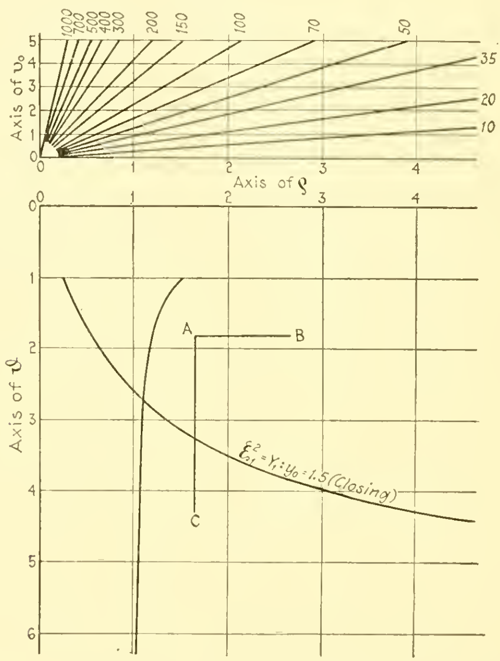


FIG. 1 ABACUS FOR CALCULATING, AND CARTESIAN SYNOPSIS OF, WATER HAMMER PHENOMENA IN DIFFERENT CONDUITS

other, though always within the limits of technical application. Thus the two conduits characterized by the following elements:

(1) $y_o = 300$ m.; $a = 1000$ m./sec.; $L = 900$ m.; $v_o = 3.60$ m./sec.; $\tau = 9$ m./sec.

(2) $y_o = 100$ m.; $a = 840$ m./sec.; $L = 300$ m.; $v_o = 1.43$ m./sec.; $\tau = 3.6$ m./sec.

though entirely dissimilar are represented by the same pair of parameters

$$\rho = 0.60 \quad \text{and} \quad \vartheta = 5.$$

Out of the five elements characterizing a conduit under normal operating conditions, three are constructive and usually invariable: y_o, a and L, while the other two are functional, v_o and τ, their magnitude undergoing frequent and important modifications, as e. g., in closing or opening the closing gate, or otherwise varying the flow in the conduit. It is therefore important clearly to realize

that, when one of these functional elements is changed, the conduit, in as far as the occurrence of water hammer is concerned, *becomes practically a new conduit*, in which the laws governing these phenomena may produce actions entirely different from those produced with the original values of the variable elements v_o and τ.

It appears thus that, by giving to the parameters ρ and ϑ all the values which they can have in practical applications, one may determine the double infinity of conduits which embraces all the imaginable conduits as well as all the operations of the closing gate; but each of these conduits, determined by one pair of the parameters ϑ and ρ, represents in reality a triple (or double) infinity of conduits in which the water hammer rises to the same relative values and follows the same laws. And it is this particular grouping of all the imaginable conduits which makes possible a systematic and complete study of the water hammer and full understanding of the theory of those phenomena. From these considerations is naturally derived the idea of *cartesian synopsis*, which, in the case of conduits, is obtained by representing graphically, on a system of rectangular coördinates ρ and ϑ (Fig. 1B) all the laws governing the phenomena of water hammer, i. e. the deductions which may be derived from the fundamental system of equations (more about this graphical system of representation will be said later).

Since the characteristic ρ varies between 0.10 and 10, the ratio W_o:W, kinetic energy to potential energy, varies between 0.04 and 400, or in the ratio of 1:10,000, which explains why the phenomena of water hammer, functions of the relative values of these two quantities of energy, are apt to attain relatively widely varying values and to follow quite different laws, in accordance as one has to deal with low or high heads, as will be proved later.

Internal Combustion Engineering

Application of Diesel Engines to War Vessels (*Application des moteurs Diesel aux navires de guerre*, P. Dumanois. *La Technique moderne*, vol. 7, no. 8, p. 257, October 15, 1913. 3 pp., 1 fig. *mA*). In a previous article (*The Journal*, June 1913, p. 1052) the author showed that there occur in large Diesel engines far higher pressures than was usually supposed. In this article he discusses the problem of heat elimination from the cylinder of the large Diesel engine, and shows that here again are little understood difficulties in the way of building large units.

Influence of the thickness of walls of the combustion chamber. Let θ be the temperature of the gas in the cylinder; T_1 temperature of the wall inside the combustion chamber; T_2 temperature of the wall outside the combustion chamber; T_3 temperature of the cooling water; s area of the surface of the inner walls of the combustion chamber; S area of the surface in contact with the cooling water; ϵ thickness of the wall; K coefficient of heat emission of the gas (heat emitted per hour per meter square); K' coefficient of transmission of heat between the external wall and the cooling water (heat transmitted per hour per meter square); C coefficient of conductibility of the metal of the wall; θ, T_1, T_2, s are functions of the angle of crank ϕ.

In accordance with the theories of Nadal and Kirsch on the influence of walls in steam engines, fully applicable in this case, the average temperature T inside the wall may be represented by the formula:

$$T = A_o - Bx + A_1 e^{-mx} \cos(\varphi - a_1 - mx)$$

where x is the thickness from the inner wall out; A, B, A_1, m and a_1 are constants.

At each point of the wall, the temperature oscillates in the neighborhood of the value corresponding to the straight line $T = A_0 + Bx$.

On the other hand the amplitude of oscillations decreases very rapidly on account of the presence of the member e^{-mx}, and can be considered as zero from a certain value of x up, this value being only a few millimeters. In this way, the mass of the cylinder walls acts as a sort of thermal flywheel, and T_2 is practically constant all along the external wall. Therefore, under permanent conditions of operation, the quantity of heat A taken up per hour by the cooling water is equal to

$$Q = \frac{K}{\Phi}\int_0^{\Phi} s(\theta - T_1)d\varphi = \frac{C}{\epsilon}S(T'_1 - T_2) = SK'(T_2 - T_3)$$

where φ is the angle described by the crank in an hour, and $T'_1 = \frac{1}{\Phi}\int_0^{\Phi} T_1 d\varphi$.

From this expression the author derives the following equation:

$$\frac{\frac{1}{\Phi}\int_0^{\Phi} s(\theta - T_1)d\varphi}{S(T'_1 - T_3)} = \frac{CK'}{K(C + K'\epsilon)}$$

But T_3, the temperature of the cooling water does not vary much, and therefore T'_1 and T_1, both of which vary in the same sense, increase when ϵ increases, which means that the temperature of the inner wall approaches that of the gas when the thickness of the wall increases. There is therefore a certain limiting value to the power that may be derived from a single cylinder, this limit being reached when the temperature of the inner wall rises high enough to cause a decomposition of the lubricating oil with its attendant troubles. The theoretical determination of this limit is scarcely possible at the present time, especially as the value of K on which it depends to a considerable extent is not exactly known But the data from tests made with a 400-h.p. two-stroke cycle Koerting engine have shown that at certain points the temperature of the walls is in the neighborhood of 200 deg. cent. (392 deg. fahr.).

The author shows further that, in a large engine, the usual arrangement of piston directly connected with the crosshead-pin is unsuitable because it forces the piston and cylinder to support the reactions normal to the walls of the latter and due to the obliquity of the connecting rod. The only duty that may therefore be imposed on the piston is that of securing a close packing for the volume varying at each instant, and of transmitting the normal reactions to a special mechanical organ, which is nothing else than the crosshead beam and slide-bar of the steam engine, the use of which, while securing a higher safety of operation, rather complicates the design of the engine.

The cooling of the piston. As regards the action of heat on the different parts of the combustion chamber one finds that during the entire periods of expansion and exhaust, the inner wall of the piston head and of the cylinder head are in contact with the hot gases, while the different parts of the cylinder walls are in contact with them only for a fraction of the time, and therefore the piston head and cylinder head have a tendency to acquire a higher average temperature than the walls of the cylinder. In addition, in the Diesel engine there is a calorific

lack of symmetry due to the method of injecting the fuel. The piston head receives during the entire period of injection the shock of the hot gases, and, if the average temperature of combustion does not exceed 1550 deg. cent. (2822 deg. fahr.), one may reasonably assume that the temperature of the gas jets burning under considerable pressure under conditions similar to that of a welding burner, must be substantially above the average. This flame acts probably in two ways, first, tending to break up the surface of the piston head by its kinetic energy, and then modifying the physical structure and chemical constitution of the surface layers of metal by its high temperature and carburizing action. These actions are only to a limited extent minimized by the use of diffusors spreading the jet over a wider area. In slow running engines with low power output the cooling of the cylinder and piston head does not present any serious difficulties, but in the case of large engines running at high speeds water cooling of the piston has to be used, and this involves mechanical complications and danger of water leaks into the crank case; further, in some cases, where a mixture of sea water with the lubricant appeared to be objectionable, cooling of the piston by oil circulation had to be adopted. The importance of the above considerations becomes clear when one remembers that for driving battleships, engines will have to be used with an output of at least 1000 h.p. per cylinder.

The Oil Engine of the German General Electric Company (*Die AEG-Oel-maschine. Oel-und Gasmaschine*, vol. 13, no. 7, p. 97, October 1913. 3 pp., 7 figs. *d*). The purpose of the described engine was to provide an economical and easily handled prime mover for outputs under 500 h.p. for which the steam turbine is not economically efficient. The engine is built in four types, two, three and four cylinders, 125 h.p. per cylinder. It is of the two-stroke cycle Diesel type, approaching in its construction the so-called Oechelhauser design. There are in each cylinder two pistons which at one dead point are at minimum, and at another dead point at maximum distance from one another. One of these pistons covers and uncovers the passage for the escape of the products of combustion from the working cylinder, the other piston similarly operates the slots admitting the air for the next cycle. The heavy and unwieldy valves for the admission of air and exhaust of gases are therefore eliminated, and there remain only two valves, one for the admission of fuel, and the other for compressed air for starting. At the same time, since the slots may be made all around the cylinder, there is plenty of room for making them large enough for the most economical working of the engine. The combustion occurs with the pistons at the closest distance; the pistons are driven apart, and first the exhaust slots are opened by the upper piston, and then the air admission slots by the lower one; this fresh air acts somewhat like a piston, and thereby helps to drive the gases of combustion out in the most economical manner. The thorough and still economical manner of scavenging is the reason why the described engine, notwithstanding extremely generous dimensions of all bearings and journals, is as economical with respect to fuel consumption as the slower running four-stroke cycle engine. Owing to the very short time available for the admission of fresh air into the cylinder, and the low pressure used, a scavenging pump must be employed. It is connected with the working cylinder by placing its cylinder with its piston under the working piston, but in the AEG-oil engine the fresh air pump *C* (Fig. 2) is driven by a separate crank placed at the end of the crankshaft opposite the dynamo side. Immediately above the scavenging pump is

located the two-stage air compressor *D–E* for the compressed air for injecting the fuel. The scavenging pump compresses the air to a comparatively low pressure. The modern development of the oil engine is preferably in the direction of the two-stroke cycle type, where complete replacement of the gases of combustion by fresh air and economical use of compressed air are the fundamental conditions of economical operation, while the pressure of the air used for scavenging must also be selected with due regard to economy.

Regulations for the Use of Liquid Fuel Locomotives Underground (*Bedingungen für den Lokomotivbetrieb mit flüssigen Brennstoffen unter Tage. Braunkohle*, vol. 12, no. 28, p. 486, October 10, 1913. 2 pp. *g*). Regulations for the use of locomotives using liquid fuel underground published by the Halle Royal Mining District Administration. The regulations order, among other

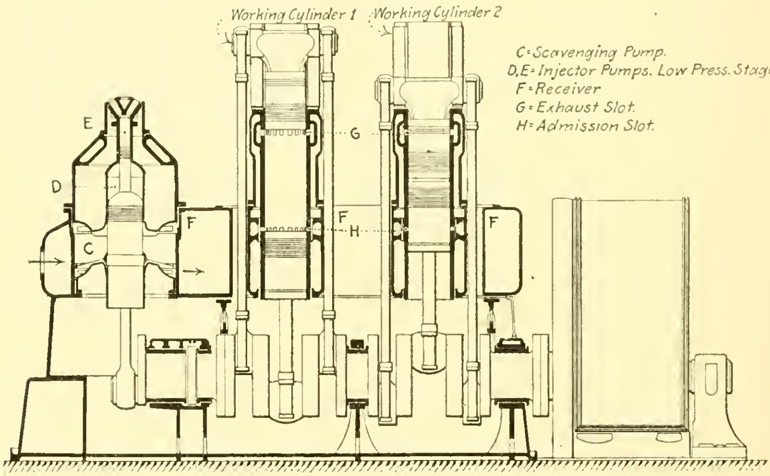


Fig. 2 Oil Engine of the German General Electric Company

things, that the locomotives may be filled with fuel only in special rooms, where facilities are provided for effectively preventing all spilling of the fuel on the locomotive or into the room; that no fuel may be used for other purposes, such as cleaning, and that in case of fire, all the openings in the room must be immediately and completely closed. Special provisions are made for the safety of the room where the locomotive is filled with fuel, such as the use of fireproof doors which may safely be closed from outside, use of electric light or safety lamps, and signs prohibiting the entrance of persons not employed on the premises. Locomotives left without attendance must have their starting crank removed, or otherwise made safe against being started accidentally. The construction of locomotives is prescribed so as to exclude the possibility of fire emission either through the air suction, or gas exhaust pipes. The locomotive engineer must be at least 21 years old.

Direct Reversal of Internal-Combustion Engines (*Die unmittelbare Umsteurung der Verbrennungskraftmaschinen*, Pöhlmann. *Verhandlungen des*

Vereines zur Beförderung des Gewerbefleisses, no. 7, September 1913. p. 309, 84 pp., 97 figs. *d.* Article not finished). Discussion of various systems for the reversal of internal-combustion engines of various kinds. The author attempts to prove that, as far as reversibility is concerned, the internal-combustion engine is at least as good, in some respects even better than the steam engine, and that while the reversing in construction is somewhat complicated, it is simple and reliable in operation.

Lubrication

Some Experiments on Combined Oil and Graphite Lubrication (*Alcuni esperimenti sulla lubrificazione combinata con olio e grafite,* A. Mosser. *L'Industria,* vol. 27, no. 41, p. 658, October 12, 1913. 2 pp., 7 figs. *e*). The author made some tests on friction in lubricated parts, using both pure oil and oil mixed with oildag (1.7 and 4 per cent of the latter), and found that the presence of oildag unfavorably affected both the rise in temperature and friction. Two series of tests were made: one at constant temperature, with a Thurston testing machine, and another at variable temperature, the diagrams in the latter case being taken automatically by an Ossag-Wendt machine.

Mechanics

Hydroplanes and High-Speed Cars with Aerial Propeller Drive (*Gleitboote und Schnellwagen mit Luftschraubenantrieb,* Bejeuhr. *Dingler's polytechnischers Journal,* vol. 328, no. 44, p. 698, November 1, 1913. 1 p., 2 figs. *d*). The aerial propeller becomes of steadily growing importance as a means of propelling vehicles along the surface of the earth and water. In France Tellier built for a private sportsman a hydroplane with an aerial propeller drive which on trials developed a speed of 70 km. (43 miles) per hour. The boat has three floats, of the hydroaeroplane type, with one float in front of the other two, all the floats being connected with the boat hull by steel tubes. A 50-h.p. Daimler-Mercedes water cooled engine, placed rather low, transmits its power through a chain drive to a Levavasseur propeller high above it, having a diameter of 2.8 m. (9 ft. 2 in.). The fuel is delivered to the engine under pressure. The high speed of the boat was probably due partly to the fact that, at full speed, the floats were immersed in the water not more than 3.5 in. (9 cm.).

Another application of the aerial propeller was developed to answer concrete practical requirements. The French government maintains an aeronautical station at Biskra, Northern Sahara, where tests are constantly carried on on the behavior of flying machines of various types under the exacting conditions of tropical temperature and desert sand. Considerable trouble has been experienced by rescue parties for aeroplanes stalled in the desert, as automobiles of the usual types are unable to travel along the shifting Sahara sands. To remedy this condition, Lieutenant Lafargue and Engineer Cros have developed a light car driven by a four-blade aerial propeller, and traveling on 12 light pneumatic tire wheels set in pairs. The propeller is driven by a 50-h.p. Gnome engine. During the tests of the car made at Biskra it handled without trouble stiff sand hills at the rate of 25 km. (15.5 miles) an hour, and traveled along shifting sand without any trouble from the sinking of wheels.

Concerning New Mechanical Models and Demonstration Experiments (*Über neue mechanische Modelle und Vorführungsversuche,* A. Lechner. *Zeits. des*

Vereines deutscher Ingenieure, vol. 57, no. 42, p. 1674, October 18, 1913. 2 pp., 8 figs. *d*). Description of several models for use in lectures and school teaching, for the demonstration of mechanical theorems. The models described comprise demonstrations for showing precession motions or a rotating disc, and permit of making quantitative determinations of this phenomenon in accordance with the Poggendorf theory of gyration; another model exhibits the advance in the spring point and motion of the polar star from east to west; a third shows the influence of the moment of deflection on the operation of an engine. Other models demonstrate the mass action, rise of critical velocities, and influence of a non-free axis of an engine on the occurrence of vibrations in a foundation; determination of the center of gravity, etc.

Concerning Graphical Solution of Problems of Torsion (*Zur graphischen Lösung des Torsionsproblems*, A. Lechner. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 29, p. 452, October 20, 1913. 3 pp., 2 figs. *mtA*). Brief, but interesting mathematical treatment of the graphical solution of problems on torsion. After recapitulating the fundamental equations of the theory of elasticity relating to torsion, the theory of St. Venant and the Thomson analogy, the author derives expressions analogous to those used in hydromechanics, of "form" and "form difference," and shows how, successively, the stress lines in the case of torsion may be constructed, as is done in certain hydromechanical problems. In technical problems it is often of importance to know the distribution of shear stresses in a cross-section. This may be shown at once by means of stress lines and their trajectories; where the lines crowd, the stress is large, and the entire system of curves follows the law of "constant specific form difference." This process may be used also quantitatively.

Refrigeration

Data on Power Consumption and Output of Air Liquefaction and Oxygen Manufacture Plants (*Angaben über Kraftverbrauch und Leistung von Luftverflüssigungs- und Sauerstoff-Anlagen*, R. Mewes. *Zeits. für Sauerstoff- und Stickstoff-Industrie*, vol. 5, no. 19, p. 317, October 4. 1913. 1½ pp. *cA*). Data on power consumption of air liquefaction plants. The author objects to some of the data on power consumption cited in G. Claude's recent book on *Liquid Air*. He gives tabulated data which show that at present the output of liquid air per h.p-hr. varies approximately from 0.05 to 0.14 liters, the higher values being due to the use of improved counter-current apparatus. The new Mewes air liquefaction apparatus uses, e.g., in its counter-current appartus eight serpentines (Tripler coils).

Steam Engineering

The New Superheated Steam Compound Locomobile Built by R. Wolf on the Adria Exhibition in Vienna (*Die neue Heissdampf-Verbund-Lokomobile Bauart R. Wolf auf der Adria-Ausstellung in Wien*, V. Müller. *Elektrotechnik und Maschinenbau*, vol. 31. no. 41, p. 870, October 12, 1913. 2½ pp., 6 figs. *d*). This locomobile has a peculiar arrangement of cylinders necessitated by the desire to obtain as high a steam economy as possible. As shown in Fig. 3A, the slide valve chests are placed close

to the cylinders, while the high and low-pressure cylinders are placed close to each other. The valve governing the exhaust of steam from the high-pressure cylinder and the inlet to the low-pressure cylinder provides the shortest possible path for the steam from the high to the low-pressure side, while in the low-pressure cylinder the exhaust openings are along the piston motion and are covered and uncovered by the steam piston. The piston valve on the high-pressure side takes care therefore only of the phases of pre-admission and cut-off for the high-pressure cylinder. The arrangement of the valve chests and cylinders as well as the direction of the flow of steam through them is schematically indicated in Fig. 3B. Balanced piston valves with elastic packing rings of the special type developed by the R. Wolf concern have been used.

Two New Fittings for Steam Boiler Plants (*Zwei neue Armaturen für Dampfkesselanlagen. Der praktische Maschinen-Konstrukteur*, vol. 46, no. 21, p. 58 (*Dampferzeuger*), October 1913, 1 p., 6 figs. *d*). Description

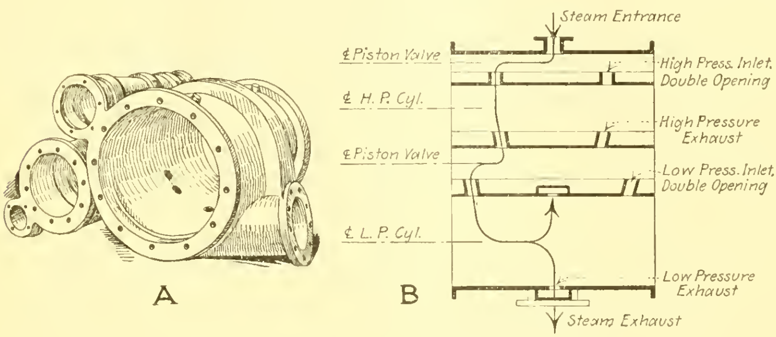


Fig. 3 R. Wolf Superheated Steam Locomobile

of the Ferranti steam valve and pressure regulating valve for simultaneous use with live and exhaust steam. It is to be used in cases where exhaust steam has to be helped out by the admission of live steam, the latter being admitted independently, and the volume and pressure of both kinds regulated in accordance with the conditions of operation of the plant. The regulating device must therefore permit, when necessary, of letting the exhaust steam into the atmosphere. All this required a rather complicated combination of devices, which the new apparatus claims to combine in a single apparatus. It consists (Fig. 4) of two combined elements, *b* for exhaust steam, and *l* for live steam; *b* is a piston valve moving in a slotted guide. In the valve *b* there is another valve *e* which is held, by means of a spindle and butterfly wing, in the casing *D* in such a manner that the lower edge of its cone closes the distributing slot in the guide cylinder along the upper edge of its cone. The piston valve *b* stands further in connection with the spindle *g*, the latter being acted upon by the lever *k* and live steam valve *f*. The interdependence of the parts *c*, *b* and *f* is what insures the automatic operation of the device.

The Development of the Oerlikon Steam Turbine (*Die Entwicklung der Oerlikon-Dampfturbine*, J. Karrer. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 43, p. 1698. 7 pp., 26 figs. *dh*). Semi-historical description of the Oerlikon steam turbine gradually developed from the Rateau impulse turbine. Prof. A. Stodola tested a 628-kw Oerlikon mixed pressure turbine, and found the efficiency of the low-pressure part to be 80 per cent (not considering bearing friction and radiation losses); the efficiency of the entire aggregate was found to be 75.4 per cent. In the high-pressure part four wheels ran in the pressure of the incoming ex-

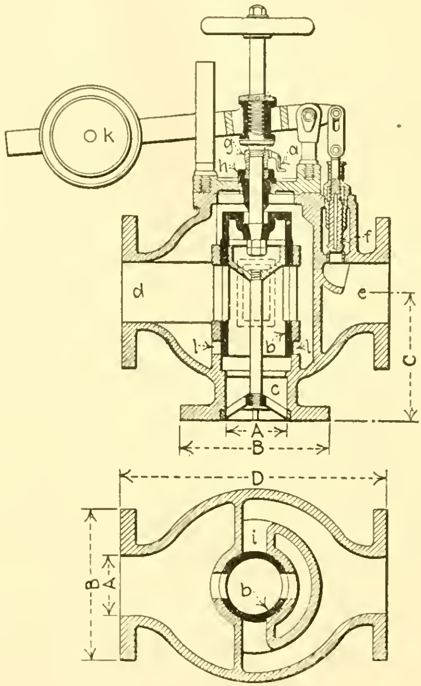


Fig. 4 Ferranti Pressure Regulating Valve

haust steam at no-load, which constituted a loss of 19 kw, or 3 per cent of the total load.

Stresses in the Blading of Ship Turbines due to Dynamic Effects and Their Relation to Ruptures of Blades (*Die Beanspruchung der Beschaufelung von Schiffsturbinen durch dynamische Wirkungen und ihre Beziehung zum Schaufelsalat*, Schumacher. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 42, p. 1668, October 18, 1913. 4 pp., 3 figs. *ml*). Dynamic stresses arising when the speed of a steam turbine is changed may under certain conditions prove dangerous for the blades of the turbine, either when, owing to excessive bending oscillations, the blades of the runner run into those of the guide, or when, owing to repeated stresses,

the material of the blades deteriorates and finally breaks; the latter usually happens so that the runner blade cracks near its root, and the free end sticks out and strikes the guide blades. The danger of such occurrences is the least in the case of turbines which allow a considerable axial play, and employ only comparatively short blades; it is minimized by having the elastic limit of the blade material as high as possible, and its specific weight as low as possible, and decreases in inverse proportion to the square of the blade thickness.

Novelties in Locomotive Construction on the Prussian-Hessian

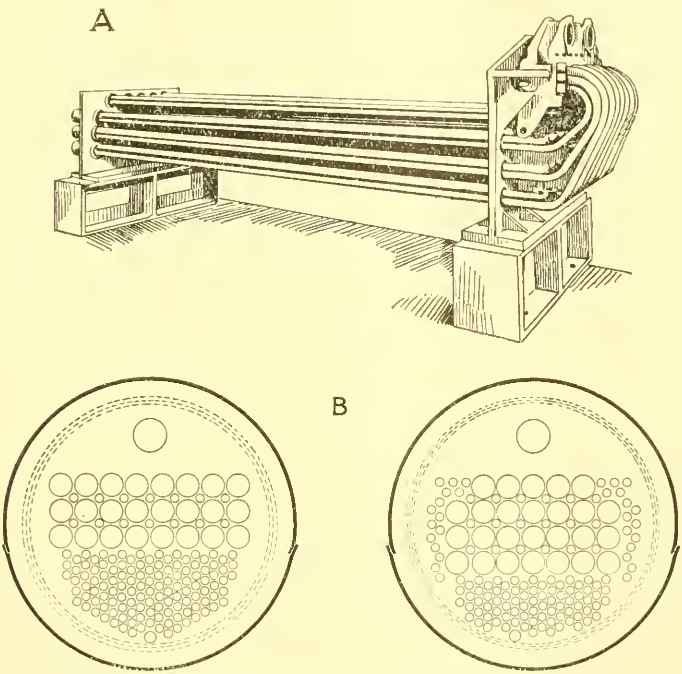


Fig. 5 New German Superheated Steam Four Cylinder Locomotive

State Railroads (*Neuerungen an Locomotiven der preussisch-hessischen Staatseisenbahnen*, G. Hammer. *Glasers Annalen für Gewerbe and Bauwesen*, vol. 73, no. 872/8, p. 136, October 15, 1913. Serial article, not finished. *d*). Description of the 2C type fast-train superheated steam four-cylinder locomotive. When the first locomotives of this type were built, there were numerous cases of bridge ruptures in the upper corner of the copper tube plate of superheated locomotives, all the ruptures having apparently the same look. Previously undesirable phenomena of throttling have been also observed in the superheater, and therefore in the new type a different superheater and fire tube arrangement have been provided, viz., instead of the usual three horizontal batteries of superheater elements,

eight in a row, four horizontal rows are now used, the upper row of five, and the other three of seven tubes each. There are therefore 26 tubes instead of 24, with but a slight decrease of the surface of evaporation, due to the fact that to the right and left, instead of the eliminated smoke tubes, ordinary flue tubes are installed. A greater freedom for the expansion of the firebox is thus provided, and a longer life of the tube walls expected. Fig. 5A shows the new arrangement of the superheater, and Fig. 5B the old (left) and new (right) arrangement of the flue and smoke tubes of the locomotive.

Strength and Testing of Materials

Data of Tests of an Exploded Steam Autoclave (*Prüfungsergebnisse eines explodierten Dampffasses*, G. Goldberg. *Zeits. für Dampfkessel und Maschinenbetried*, vol. 34, no. 43, p. 523. 1½ pp. *e*). The material of a steam autoclave which exploded while in operation was tested at the Royal Testing Laboratory of Gross-Lichterfelde West. It served for melting an organic compound under a pressure of 15 to 18 atmospheres, by the heat supplied from outside by a lead-zinc bath at a temperature of 250 to 450 deg. cent. (482 to 842 deg. fahr.). The material was wrought-iron sheets supposed to be protected on the inside by a cast-iron jacket (it was found that actually only the barrel, and not the cover was protected by such a jacket). The investigation after the explosion showed that the cast iron fitted quite loosely on the wrought-iron sheets, and easily fell off when the piece was sawed through. Both the barrel and the cover burst in the explosion.

Test pieces taken from parts of the boiler in the neighborhood of the ruptured section, were tested partly at the outside air temperature, and partly heated up to 900 deg. cent. (1652 deg. fahr.). Tension and bending tests showed that the material fully answered to the usual requirements, and still the fact remained that it burst explosively. Another series of tests was therefore undertaken. Four fine-line crosses were made on a strip of metal cut from the cover, 35 mm (1.4 in.) wide, two crosses on each side of the strip, and the distance between them carefully measured by a comparator. The parts between the cross marks were then cut out by a planer, and the distances measured a second time. It was now found that while the distance on one side slightly decreased, that on the other side increased, which shows that one side was under compression, and the other side under tension. Neither the metallographic, nor the chemical investigation gave any indications of serious deviations from the normal conditions in metal of that class, and it appeared as if the cause of the explosion would remain a mystery. This mystery was partly solved by means of the notch shock test, which shows once more the importance of this method of testing boiler plates. The material, when tested at room temperature, had a very low coefficient of bending (practically zero), usually broke at the first blow, and appeared to be decidedly brittle. When the test pieces were heated for half an hour at 500 deg. cent. (932 deg. fahr.) and tested after being cooled in the air, the results were much better, and still better for pieces heated up to 900 deg. cent. (1652 deg. fahr.). It appears therefore that the brittleness of the material at the time of

the explosion was due neither to original defects, nor to overheating of the material, since overheated material would have to be annealed at 900 deg. cent. (1652 deg. fahr.) to show a material improvement, while here an improvement was observed already at 500 deg. cent. (932 deg. fahr.). The brittleness was not due to the presence of the cast-iron jacket either, since parts not jacketed were as bad as those covered by cast iron. Further tests were made with test pieces heated in a Heraeus electric furnace to 200, 300, and 400 deg. cent. (392, 572, and 752 deg. fahr.), as rapidly as possible taken out from the furnace, and tested under shock. The highest values were obtained for pieces heated to 200 deg. cent., while the values corresponding to higher temperatures proved to be lower, though superior to those obtained at room temperature. It appears therefore that,

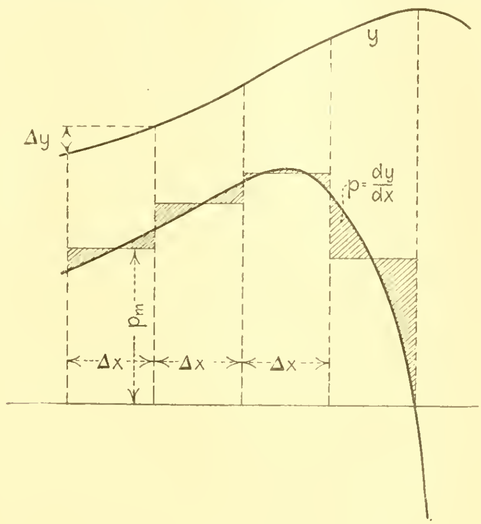


FIG. 6 GRAPHICAL DIFFERENTIATION

while nothing absolutely certain as to the cause of the explosion could be established, it was probably due to the fact that the boiler was stressed mainly at temperatures between 200 and 300 deg. cent. (392 and 572 deg. fahr.); at this temperature internal strains were produced which, after the material was cooled, led to the appearance of brittleness, these changes in the structure of the material being of such a nature as to be intensified by repeated action of the causes which originally produced them.

The main interest of this investigation lies in the fact that the usual tension and bending tests, metallographic and chemical investigations did not contribute much towards the explanation of the explosion, and that it was mainly the notch shock test that did it.

Miscellanea

A SIMPLE AND EXACT METHOD OF GRAPHICAL DIFFERENTIATION (*Ein einfaches und genaues Verfahren der graphischen Differentiation*, H. Holzer.

Zeits. für das gesamte Turbinenwesen, vol. 10, no. 29, p. 455, October 20, 1913. 1 p., 1 fig. *p*). The proposed method is based on the fact that differentiation may be considered as inverted integration. To find an integral of some curve $p = f'(x)$ (cp. Fig. 6), one has only to plot the areas $p_m \Delta x$ of the curve p to some scale as ordinate difference Δy of the integral curve y. Inversely, the ordinate differences Δy of the integral curve y will give the dimensions of the corresponding areas $p_m \Delta x$ of the differential curve p, and thereby, since the basis Δx in both curves is the same, the magnitude of p_m. This permits of determining the average heights of p_m of the succeeding areas of the curve elements, and all that remains is to plot the differential curve in such a manner that it shall give sections of equal area, the average height p_m being used. If the sections Δx be selected equal, the difference of ordinates Δy of the given curve may be used for the average height p_m of the section areas of the differential curve. It is, however, of advantage to multiply Δy by some integer in order not to obtain differential curves that are not too flat.

Garbage Incinerator Plant at Trieste (*I forni d'incinerimento delle immondizie á Trieste*, G. P. *L'Industria*, vol. 27, no. 42, p. 674, October 19, 1913. 2 pp., 2 figs. *d*). Description of the Trieste garbage incinerator plant. It is of the Herbertz type, with the Herbertz device for treating slags by dropping them into cold water and thus disintegrating. The plant has two batteries of furnaces, each of three chambers, and each with a daily capacity of handling 90 tons of garbage. The heat developed from the battery (only one battery at a time is used now, the other being for reserve purposes and future developments only) is used to drive two Tosi 300-h.p. steam engines, in their turn driving electric dynamos. The slags, broken up and sorted, are sold.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

Das Acetylen, J. H. Vogel. *Leipzig, 1911.*

Air Brake Association. Proc. 20th annual convention, 1913. *Boston, 1913.* Gift of the Society.

Alternating Currents and Alternating-Current Machinery, D. C. Jackson and J. P. Jackson. New edition. *New York, The Macmillan Co., 1913.*

The new edition of this well-known work contains a wealth of new matter, as is rendered necessary by the development of the art. While primarily designed for a textbook, it should have value to the graduate engineer, as embodying the latest theories and practice.

American Bridge Company of New York. Specifications and Tables for Steel Framed Structures. *New York, 1913.* Gift of company.

American Civil Engineers' Pocket Book, Mansfield-Merriman. ed. 2. *New York, 1912.*

American District Steam Co. bul. nos. 111, 112, 115, 116, 117, 121, 122, 124, 125, 131. *Chicago, 1908–1913.* Gift of company.

American Railroad Economics, A. M. Sakolski. *New York, 1913.*

This work treats of the character of transportation facilities; the efficiency and economy of operation; revenue, expenses and net earnings; capital investment in its relation to corporate resources and liabilities. The author is lecturer in the New York University School of Commerce.

American Tool Making and Interchangeable Manufacturing, J. V. Woolworth. ed. 2. *New York, 1911.*

American Woods, R. B. Hough. ed. 2, 3. *Lowville, N. Y., 1894–1895, 1897–1900, 1903–1904, 1910–1911.*

Associated Metal Lath Manufacturers. Report of Tests of Partitions by Fire and Water, June 28–29, 1912.

———Standard Specifications for Exterior Plastering (Stucco), August 1913. Gift of manufacturers.

Beiträge zur Geschichte des Dieselmotors, P. Meyer. *Berlin, 1913.*

Beton-Kalender Taschenbuch für den Beton und Eisenbetonbau. vol. 9, 2 pts. *Berlin, 1913.*

Business Methods in Municipal Works. An informal record of the operations of the Department of Public Works of the City of Philadelphia, under the administration of Mayor Blankenburg. *Philadelphia, 1913.* Gift of M. L. Cooke.

Cambridge (Mass.) Water Board. Annual Report, April 1912–April 1913. *Cambridge, 1913.* Gift of board.

Carburetters and Carburation: A Study of the Different Types, Douglas Leechman. *London, 1909.*

Civil Engineers' Pocket-Book, A. I. Frye. *New York, 1913.*

Concrete in Mine Construction, A. F. Allard. *Chicago, Universal Portland Cement Co.* Gift of company.

The "Demoiselle" Santos-Dumont's Monoplane, How to Build, A. A. Joeřin and A. Cross. With set of working drawings. *Chicago, 1910.* Gift of L. Goldmerstein.

Diagram giving Stresses in Beams, H. R. Thayer, assistant professor of Structural Design, Carnegie Institute of Technology.

Economic Combustion of Waste Fuels, D. M. Myers. Reprinted from Engineering Magazine, April–June 1913. *1913.* Gift of author.

Edinburgh University. Calendar, 1913–1914. *Edinburgh, 1913.* Gift of the Society.

Edwards's 900 Examination Questions and Answers for Engineers and Firemen, E. Edwards. *Philadelphia, 1912.*

Electric Power from the Mississippi. ed. 3. *Keokuk, 1913.* Gift of Mississippi River Power Co.

Engine Construction and Practise, N. S. Hill, Jr. Gift of author.

Zur Erinnerung an den Besuch der American Society of Mechanical Engineers in New York, A. Borsig, Berlin. *1913.* Gift of the Society.

Die Gas Turbine, Aladár Zsélyi. *Berlin-Charlottenburg, 1913.*

Hausheer and Gallardo. Circular no. 78. Patents and Trade Marks in South and Central America. *Buenos Aires, 1913.* Gift of Messrs. Hausheer and Gallardo.

An Investigation of the Second Law of Thermodynamics, J. T. Wainwright. *Chicago, 1913.* Gift of author.

This is an attempt to prove that the second law of thermodynamics is really not as firmly established as is generally assumed.

Jahrbuch der Wissenschaftlichen Gesellschaft für Flugtechnik. vol. 1, 1912–1913, no. 2. *Berlin, 1913.*

Jigs and Fixtures, F. H. Colvin and L. L. Haas. *New York, 1913.*

Kinetic Effects of Crowds, C. J. Tilden. Reprint from American Society of Civil Engineers. Trans. vol. 76, 1913. Gift of author.

Kraftgas, Ferd. Fischer. *Leipzig, 1911.*

Die Kunst in Industrie und Handel. Jahrbuch des deutschen Werkbundes. Verlegt bei Eugen Diederichs, in Jena, 1913. Gift of Conrad Matchoss.

This volume is of particular interest, as it shows in its wealth of illustration how factories, shops, warehouses and even shop windows can, while being planned for the greatest utility, at the same time show the greatest artistic beauty. It illustrates the attempt to make every-day structures of artistic quality.

Lehrbuch des Maschinenbaues, Karl Esselborn. vol. 2. *Leipzig-Berlin, 1913.*

Vol. 1, materials of construction, strength of materials, mechanical drawing, elements of machine design, machines with pistons, windmotors, rotary machines, steam boilers, fuel gas producers.

Vol. 2, dynamo machines and electric motors, machines for lifting (pulleys, winches, cranes), machines used in engineering contract work, hydraulic power plants, machines for planing, boring, sawing, etc., wood and metals.

A new profusely illustrated handbook of machine design and mechanical engineering, in which the various chapters are prepared by engineering specialists and experts, with a view of forming not only a textbook for students of this branch of engineering, but also a handy reference book for the practising engineer. The work has been very favorably received and reviewed by the German technical press.

Leitfaden der Flugtechnik, S. Huppert. *Berlin, 1913.*

Leitfaden zum Berechnen und Entwerfen von Lüftungs-und Heizungs-Anlagen, H. Rietschel and K. Brabbée. ed. 5, vols. 1–2. *Berlin, 1913.*

Leland Stanford Junior University. Register, 1912–1913. *1913.* Gift of university.

The Locomotive. vols. 26, 27. *Hartford, 1906–1909.* Gift of Hartford Steam Boiler Inspection and Insurance Co.

Machine Shop Tools and Methods, W. S. Leonard. ed. 6. *New York, 1911.*

Municipal Engineers of the City of New York. Proc. 1904. *New York, 1905.* Gift of society.

Die Nebenprodukte der Leuchtgasfabrikation, K. R. Lange. *Berlin-Leipzig, 1913.*

New Jersey. Board of Public Utility Commissioners. 3d Annual Report, 1912. *Union Hill, 1913.* Gift of commissioners.

Official American Textile Directory. 1913. *Boston, 1913.*

Practical and Scientific Management, G. Schlesinger. *Charlottenburg.* Gift of Society.

Practical Stationary Engineering in Form of Questions and Answers, A. C. West. *Boston, 1909.*

Press Reference Library (Western Edition). vol. 1. *New York, International News Service, 1913.* Gift of Los Angeles Examiner.

Properties and Power Developments of the Nevada-California Power Company and Southern Sierras Power Company. Reprint from Journal of Electricity, Power and Gas, July 5, 1913. *San Francisco, 1913.* Gift of G. J. Henry.

Relation of Water to Chronic Intestinal Tract Infection, N. S. Hill and L. R. Whitcomb. Reprinted from American Journal of Public Health, vol. 3, no. 9. Gift of N. S. Hill.

La Resistenza delle Artiglierie. *Torino, 1913.* Gift of Comm. Ettore Bravetta.

Rolling Mill Industry, F. H. Kindl. *Cleveland, 1913.*

Some Test Data on Fireproof Floor Construction relating to Cinder Concrete, Terra Cotta and Gypsum. *Clinton.* Gift of the Clinton Wire Cloth Co.

South Philadelphia. The Abolishment of Grade Crossings and the Creation of Opportunities for Commercial and Industrial Development. *Philadelphia, 1913.* Gift of Department of Public Works, Philadelphia.

Steel Designing, Edward Godfrey. *Chicago, 1913.*

University of Colorado. General Catalogue of the Officers and Graduates, 1877–1910. *Boulder, 1911.* Gift of the Society.

University of Pennsylvania. Circular of the Towne Scientific School 1912–1913. *Philadelphia, 1913.* Gift of university.

University of South Carolina. Graduate Engineer. Address delivered to the Engineering Classes by T. H. Gatlin, Columbia, 1913. Gift of university.

Verflüssigung der Luft und ihre Zerlegung, Hans Giese. *Leipzig, 1909.*

Gift of F. R. Hutton

Cooper, J. H. Treatise on the Use of Belting for the Transmission of Power *Philadelphia, 1878.*

Cromwell, J. H. Treatise on Toothed Gearing. *New York, 1884.*

Daddow, S. H. and Bannan, Benj. Coal, Iron and Oil. *Pottsville, 1866.*
Engineering Index. vols. 3, 4. *New York, 1902, 1906.*
Henck, J. B. Field-Book for Railroad Engineers. *New York, 1878.*
Locomotive. vol. 25. *Hartford, 1904–1905.*
McShane, Chas. The Locomotive Up-To-Date. *Chicago, 1899.*
Nystrom, J. W. Pocket-book of Mechanics and Engineering. ed. 12. *Philadelphia, 1873.*
Pratt & Whitney Company. Standards of Length and their Practical Application. *Hartford, 1887.*
Richter, Th. Plattner's Manual of Qualitative and Quantitative Analysis with the Blowpipe. ed. 2. *New York, 1873.*
Roper, Stephen. Hand-book of Land and Marine Engines. ed. 2. *Philadelphia, 1877.*
Sabine, Robt. Electric Telegraph. *London, 1867.*
Trautwine, J. C. Civil Engineer's Pocket-book. *Philadelphia, 1876.*
Tyndall, John. Heat considered as a Mode of Motion. *New York, 1864.*
Vose, G. L. Manual for Railroad Engineers and Engineering Students, with plates. 2 vols. *Boston, 1873.*
Welch, E. J. C. Designing Valve Gearing. *London, 1875.*
Whitney, J. D. Metallic Wealth of the United States. *Philadelphia, 1854.*
Wood, M. P. Rustless Coatings. *New York, 1904.*

Gift of Wm. Paul Gerhard

Arnott, Neil. Smokeless Fire-place. *London, 1855.*
Bohn, G. Anleitung zu Vermessungen in Feld und Wold. *Berlin, 1876.*
Brofius, J., and Hoch, R. Locomotivführer-Examen ein Fragebuch. *Wiesbaden, 1876.*
———Die Schule des Locomotivführers. *Wiesbaden, 1873.*
Corthell, E. L. History of the Jetties at the Mouth of the Mississippi River. *New York, 1880.*
Debauve, A. Manuel de L'Ingénieur. *Paris, 1875.*
Burghagen, Otto. Die Schreibmaschine. *Hamburg, 1898.*
Erfurth, C. Haustelegraphie, Telephonie und Blitzableiter in theorie und Praxis. ed. 2. *Berlin, 1888.*
Engineering Catalogues of Power Plant Equipment for the year 1913.
Engineering Record. Water Tower Pumping and Power Station Designs. *New York, 1893.*
Fort, O., and Schlömilch, O. Lehrbuch der Analytischen Geometrie. ed. 2. *Leipzig, 1863.*
Gompertz, Max. Über abgesetzte und gekröpfte Wellen. *Berlin, 1912.*
Groedel, E. E. Experimentelle und theoretische Untersuchungen an Pressluft-Hämmern. *Berlin, 1913.*
Gutachten über die Ableitung der Schmutzwässer von Mannheim nach dem Rhein, Marz 1898.
Gutachten über die Klärung des Kanalwässers von Baden-Baden. *Baden, 1894.*
Hanhart, H. and Waldner, A. Tracirungs-Handbuch für die Ingenieurarbeiten im Felde bei der Projectirung und dem bau von Eisenbahnen und Wegen. *Berlin, 1874.*

Haas, F. H. Die atmosphärische Elektrizität. *Berlin, 1892.*

Hattendorff, K. Einleitung in die analytische Geometrie. *Hannover, 1872.*

Hoch, Julius. Tiefbauzeichnen. Vorschule für das Fachzeichnen im Tiefbauwesen. *Hannover, 1900.*

Hoffmann, Albert and Wentscher, Ernst. Schreibmaschinen. *Berlin, 1893.*

Kauffmann, C. F. Lehrbuch der ebenen Geometrie. ed. 3. *Stuttgart, 1863.*

Keller, F. Sammlung ausgeführter Tunnel-und Brückenprotale. 50 Blätter mit Erklärung. *Carlsruhe.*

Knoll, Carl. Taschenbuch zum Abstecken der Kurven an Eisenbahnen und Strassen. *Stuttgart, 1873.*

Koppe, Carl. Die Aneroid Barometer von Jakob Goldschmid und das barometrische Höhenmessen. *Zürich, 1877.*

Kröhnke, H. Handbuch zum Abstecken von Curven auf Eisenbahn und Wegelinien. ed. 8. *Leipzig, 1873.*

Lübsen, H. B. Einleitung in die Mechanik. ed. 3. *Leipzig, 1869.*

Müller, Heinrich. Die wichtigsten Resultate für die Berechnung eiserner Träger und Stützen. *Berlin, 1876.*

Müller, Rudolf. Stadtische Wohlfahrtseinrichtungen. *Wien, 1910.*

Neumann, Fritz. Die Zentrifugalpumpen. *Berlin, 1906.*

Palmieri, Luigi. Die atmosphärische Elektricität. *Wien, 1884.*

Petry, Wilhelm. Die Zugbeanspruchung des Eisens im Eisenbeton bei auf Biegung beanspruchten Bauteilen. *1913.*

Reuleaux, F. Die Chemie des täglichen Lebens. *Leipzig, 1886.*

Ržiha, Franz. Eisenbahn Unter-und Oberbau. vols. 1–3. *Wien, 1876–1877.*

Schrader, W. Elemente der Mechanik und Maschinenlehre. pt. 1. ed. 2. *Halle, 1871.*

Seegers, Adolf. Illustriertes Lehrbuch des Maschinenschreibens. *Göttingen, 1901.*

Schmidt, C. H. Der praktische Maschinenrechner. ed. 3. *Berlin, 1875.*

Spitz, Carl. Erster Cursus der Differential und Integralrechnung. *Leipzig, 1871.*

———Lehrbuch der ebenen Trigonometrie. ed. 3. *Leipzig, 1870.*

Stadterweiterung Köln. Erläuterungsbericht zu dem Kanalprojecte für das mittlere Drittel der Neustadt. *Köln, 1881.*

Stampfer, S. Theoretische und praktische Anleitung zum Nivelliren. *Wien, 1877.*

Stegemann, M. Grundriss der Differential und Integral-rechnung mit Anwendungen. ed. 2. *Hannover, 1873.*

Stephen, Erich. Berechnung der homogen quadratischen Platte und deren Aufnahmeträger.

Technische Mechanik. chap. 1. Festigkeitslehre. *Stuttgart, 1875.*

U. S. War Department. bull. no. 22. Survey of Northern and Northwestern Lakes. *Detroit, 1913.*

Weisbach, Julius. Lehrbuch der Ingenieur und Maschinen-Mechanik. ed. 5, pt. 1. *Braunschweig, 1875.*

———Ed. 2, pt. 3. vols. 1–2. *Braunschweig, 1876, 1880.*

Winckel, L. Handbuch zum Abstecken von Curven. *Berlin, 1873.*

EXCHANGES

American Society of Refrigerating Engineers. Transactions vol. 8. *New York, 1913.*

Canadian Society of Civil Engineers. Index to Transactions vols. 1–24. *Montreal, 1911.*

Institution of Civil Engineers of Ireland. Transactions vol. 39. *Dublin, 1913.*

Institution of Naval Architects. Transactions vol. 55, pt. 1. *London, 1913.*

Manchester Association of Engineers. Transactions, 1912–1913. *Manchester, 1913.*

Western Australian Institution of Engineers. Proc. vols. 1–3. *Perth, 1910–1912.*

——Inaugural Address by James Thompson, March 31, 1910. *Perth, 1911.*

TRADE CATALOGUES

Albany Lubricating Co., *New York, N. Y.* The bearings, October 1913.

Bristol Co., *Waterbury, Conn.* Cat. no. 1300, class III, Recording thermometers, April 1913.

Chicago Pneumatic Tool Co., *Chicago, Ill.* Bul. 34-T, class M, "Chicago Pneumatic" Corliss type steam driven compressors, September 1913.

Johns-Manville, H. W. Co., *New York, N. Y.* J-M power expert, October 1913.

Nile-Bement-Pond Co., *New York, N. Y.* Progress reporter, September 1913.

Northwestern Expanded Metal Co., *Chicago, Ill.* Expanded metal construction, October 1913.

Under-Feed Stoker Co. of America, *Chicago, Ill.* Publicity magazine, September, October 1913.

Bristol Co., *Waterbury, Conn.* Bul. no. 143, recording differential pressure gages, April 1913; Bul. no. 171, recording shunt ammeters, July 1913; Bul. no. 172, recording tachometer, pneumatic type, August 1913; Bul. no. 173, recording differential pressure gages, float type model 1010, April 1913; Bul. no. 175, electric resistance thermometers, model 162, June 1913; Bul. no. 177, quick reading portable Wm. H. Bristol electric pyrometer, September 1913; Bul. no. 179, round form recording pressure gages, September 1913.

Ozone Pure Airifier Co., *Chicago, Ill.* Descriptive cat., 16 pp.

UNITED ENGINEERING SOCIETY

Abbreviations and Technical Terms Used in Book Catalogs and in Bibliographies, F. K. Walter. *Boston, 1912.*

American Library Association. Handbook 1913. bull. no. 5, September 1913. *Chicago, 1913.* Gift of W. P. Cutter.

American Scenic and Historic Preservation Society. Eighteenth annual report, 1913. *Albany, 1913.* Gift of society.

American Standard Flange Dimensions for Brass Flanges. Adopted September 17, 1913, by Committee of Manufacturers on Standardization of Fittings and Valves. Effective January 1, 1914.

American Standard for Flanged Fittings, Standard and Extra Heavy Pressures. Adopted September 17, 1913, by Committee of Manufacturers

on Standardization of Fittings and Valves. Effective January 1, 1914. Gift of Committee of Manufacturers on Standardization of Fittings and Valves.

HENDRICKS' COMMERCIAL REGISTER OF THE UNITED STATES FOR BUYERS AND SELLERS. 22d annual edition. *New York.*

NEW YORK TIMES INDEX. vol. 1, no. 3, July–September, 1913. *New York, 1913.*

OPISANIE SOORUSHENIG NOVAGO MOSKOVSKAGO VODOPROVODA, WITH ATLAS. In Russian. *Mockba, 1908.* Gift of Walter Wood.

RESOLUTIONS OF THE FACULTY OF CIVIL ENGINEERING OF CORNELL UNIVERSITY AND OTHER SCIENTIFIC ASSOCIATIONS, in favor of Appropriations of the continuance of the board appointed for testing iron, steel and other metals. 44th Congress, 2d Session, Senate. Mis. Doc. no. 38. Gift of W. P. Cutter.

STATESMAN'S YEAR-BOOK. 1913. *London, 1913.*

TARIFF LAW OF 1913. *New York, 1913.* Gift of W. P. Cutter.

WATER WORKS SYSTEM OF MOSCOW, RUSSIA, N. P. Simin. In Russian. *Mockba, 1905.* Gift of Walter Wood.

MEETINGS

MILWAUKEE MEETING, OCTOBER 8

The first meeting of the Milwaukee section was held October 8, when Prof. A. G. Christie, Mem. Am. Soc. M. E., of the University of Wisconsin, gave a talk on The Uses of Pitot Tubes for Measuring Air. The talk was based on the paper by Mr. Rowse published in The Journal of the Society for September. The meeting was well attended. Old and new members of the Society are joining the local section and there never was a time when greater interest was shown in the work of the Society.

ST. LOUIS MEETING, OCTOBER 15

A meeting of the Associated Engineering Societies of St. Louis, under the auspices of The American Society of Mechanical Engineers, was held on October 15. Mr. L. A. Day, mechanical engineer of the St. Louis Water Department, read the paper of the evening, The New Turbine Pumps at the Chain-of-Rocks. An interesting discussion followed, in which Prof. E. H. Ohle, John Hunter, E. H. Tenney, G. M. Peek, and Messrs. Greensfelder, Wall and Russell participated.

BOSTON MEETING, NOVEMBER 19

The November meeting was a joint meeting conducted by the Boston Society of Civil Engineers, the American Institute of Electrical Engineers and The American Society of Mechanical Engineers coöperating. The paper, entitled Engineering Lessons from the Ohio Floods, was presented by John W. Alvord of Chicago, who was retained last spring to study the effects of the floods in Ohio the early part of this year and to suggest methods for protecting the districts affected. Mr. Alvord referred first to the geographical features of the country affected, particularly up-river from Dayton and Columbus, and called attention to the extent to which building in the large cities has spread over the river plains and limited the main river bed. He pointed out the fact that the physical characteristics of the region about these cities indicated that at some time in the past, conditions had prevailed similar to those which had produced the recent floods and that the disposal of the flood water had required all the outlet afforded by the conformation of the sites. He showed how the occupation of the low lands by buildings, the restriction of the river channeds and the building of railway embankments and bridges particularly had served to dam back the flood waters and very much increase the damage done.

Attention was called to the exceedingly high velocities developed through openings in these embankments and the resulting scour; also the effect which floating buildings and other debris have in stopping up the open-

ings through bridges, especially those of heavy masonry type, and instanced cases where the difference in level between the up-stream and down-stream side of such obstructions amounted to several feet. Lantern slides were shown illustrating these various points as well as the general destruction; of these a series showing the great erosion at certain points in the river bed where huge fields of rock were fairly quarried out and distributed over large areas, was particularly striking.

The speaker described projects for the control of these rivers which included a series of emergency storage reservoirs up-river from both Dayton and Columbus. In this connection he pointed out the difference between a system with capacity for handling the whole of such an exceptional rain fall such as was practicable above Dayton and a system of only partial capacity like that suggested above Columbus; called attention to the precautions which were necessary in the latter case to prevent the spill from these reservoirs coming together at the junction of the rivers below in such a manner as to form a crest which might closely approach or equal that due to an unrestricted flood.

CINCINNATI MEETING, NOVEMBER 20

The November meeting of the Society, a joint meeting with the Engineers' Club of Cincinnati, was one of unusual interest and attracted an attendance of 120. The address of the evening was presented by Elwood Haynes of Kokomo, Ind., on the new alloy, Stellite, which has attracted so much attention for its characteristic of great hardness. The speaker referred to experiments made by him about thirteen years ago in the reduction of semi-rare metals through their compounds, and discussed the physical characteristics of chromium, cobalt, and tungsten, and the remarkable alloys formed by chromium and cobalt, and by chromium, cobalt, and tungsten. He stated that over one hundred alloys of different combinations of these three metals, together with a fourth, molybdenum, had been made by him, all of which were characterized by extreme hardness and resistance to oxidization or other chemical action; and that the name Stellite had been given to this series of alloys.

The samples shown by the speaker possessed a high lustre and extreme hardness. Some of the tools easily scratched glass and pared light shavings off of steel wire nails, apparently with no damage to the cutting edges. A hammer, a draw knife, a table knife, and several chisels were exhibited, besides several very interesting specimens of metallic cobalt, molybdenum, and tungsten. The speaker reviewed the circumstances that had prompted him to try Stellite in a boring mill, after a failure to secure the full capacity of the machine from the use of high speed steel. Up to that time he had made only small tools and tableware out of it, believing that its property of remaining untarnished would make it desirable for these purposes. The success of the Stellite tool in the boring mill led to its use in lathes for making spiral gears, resulting in a great saving. In the two instances cited, the capacity of the machines had been more than doubled. This led to its introduction to the trade as a material for metal-cutting tools.

The specimens of Stellite and tools of Stellite shown by the speaker

resembled silver and had a beautiful polish. The speaker stated that it had been used in contact with corrosive acids and was entirely unaffected by them. It, of course, contains no iron; a small amount of iron injures it and much iron ruins it. It is distinctly magnetic, though less so than iron. It is extremely hard and must be cast into shape and ground, as it cannot be machined. Some softer kinds of the alloy can be forged with some difficulty when hot; but the harder alloys retain their extreme hardness when hot, which is the reason for the admirable service the material gives as a metal-cutting tool. In many cases the capacity of machines could be doubled by its use. It is about five times as expensive as the best high speed steel. The subject was extensively discussed and great interest was shown in the specimens.

CHICAGO MEETING, NOVEMBER 19

The first meeting of the season, held at the Sherman House, was a pleasing affair, being preceded by a dinner with a hundred and sixty-two in attendance. W. F. M. Goss, President of the Society, and Ambrose Swasey, Past-President, were in attendance. The evening was devoted to an informal talk on the Iron and Steel Industry of Chicago by Wm. A. Field, general superintendent of the Illinois Steel Company at South Chicago. Mr. Field told in an interesting manner of his early experiences in the steel industry, and brought out the fact that the remarkable development of this industry has been the result of painstaking efforts to enlarge the output ratio of the plants by continuous operation, and by increases of efficiency of both men and machines, with steadily increasing wages to the former.

Past-President Robt. W. Hunt followed with an interesting account of the organization of the old North Chicago Rolling Mills, which later developed into the present South Chicago Works of the Illinois Steel Company. E. M. Hagar, President of the Universal Portland Cement Company, referred to the growth of the cement industry, which had formerly been but a weakling child of the steel plant, and has now outgrown its parent. H. J. K. Freyn called attention to the close connection between the development of the gas engine and the steel industry.

NEW HAVEN MEETING, NOVEMBER 21

The first quarterly meeting of the season in New Haven was held on Friday, November 21, in the Mason Laboratory of Sheffield Scientific School, the attendance exceeding 250, the seating capacity of the lecture room.

The afternoon session, over which E. S. Cooley, chairman of the New Haven Committee on Meetings, presided, was opened at 3 o'clock, Coöperative Industrial Research being the topic assigned. Papers were presented on Coöperative Industrial Research at the Sheffield Scientific School with Connecticut Manufacturers, by Dr. L. P. Breckenridge, professor of mechanical engineering, Sheffield Scientific School; Research Work of the Bureau of Mines, by Prof. O. P. Hood, chief mechanical engineer of the United States Bureau of Mines; Coöperatinon of State and University for Industrial Research, by Prof. A. N. Talbot, of the Engineering Experiment Station of the University of Illinois, read by Wm.

Kent Shepard; and Oxy-Acetylene Welding Applied to Boiler Seams, by Henry Cave, of the Autogenous Welding Equipment Company, Springfield, Mass., followed by a demonstration of welding and cutting by the oxy-acetylene torch.

During the intermission a test was made of an automobile, measuring the horsepower and gasolene consumption at different speeds, and a demonstration was given of the use of compressed air tools by Mr. Lawson of the Chicago Pneumatic Tool Company, using a new Sullivan two-stage compressor.

About 75 engineers sat down to dinner at 6 o'clock in the Yale Dining Club and enjoyed a social hour.

Mr. Cooley again presided at the evening session, which opened in the laboratory at 7.30 p.m. Calvin W. Rice, Secretary of the Society, made a few brief remarks on the work of the Society and the features of interest in the coming annual meeting; and papers were presented on Safety Devices used in Connection with Grinding Wheels, by R. G. Williams of the Norton Company, Worcester, Mass.; Accident Prevention in Europe and the United States, by Dr. A. D. Risteen of the Travelers Insurance Company, Hartford, Conn.; History of the Manufacture of Brass, by W. B. Edwards, of Ansonia, Conn., read by H. L. Seward; Experiments with Residence Heating Boilers at the Mason Laboratory, by D. B. Prentice, of the mechanical engineering department of Sheffield Scientific School; and Motor Car Testing, by Prof. E. H. Lockwood, of the Sheffield Scientific School. The interesting exhibits and the enthusiasm of the large number present augurs well for the New Haven meetings and repays the committee for their efforts.

A more complete account of the papers and discussions will be published in another issue of The Journal.

NEW YORK MEETING, NOVEMBER 11

The paper of the evening was by C. V. Kerr, Mem. Am. Soc. M. E., on A New Centrifugal Pump with Helicoidal Impeller. It dealt with a style of pump intended to be driven by small steam turbines in connection with the auxiliaries of power plants, or for irrigation or drainage service where large volumes of water at low lift are to be handled. The paper was profusely illustrated by lantern slides. Dr. W. F. M. Goss, President of the Society, attended the meeting and made a few remarks at the close of the paper. He said that he liked to think of the centrifugal pump or the steam turbine as a simple thing, a device responding to very simple ideals, which came into existence from the very fact that it was simple and could be easily made. In the development of these conceptions, however, we have been led up to complicated processes and it is marvelous to think what has been done in the development of the centrifugal pump —how by applying mathematics (which really is good sense systematized), by applying our knowledge of assured facts and by the employment of a proper system of analysis we can design a pump to do almost any sort of work. The paper was then discussed by Carl George DeLaval, Harry Sinclair Hillman, Frederick Ray, Selby Haar, William A. Shoudy, and John H. Lawrence.

PHILADELPHIA MEETING, NOVEMBER 19

A joint meeting of the Society and Franklin Institute was held on November 19 with an attendance of a hundred and thirty. The paper of the evening was presented by Dr. R. H. Fernald, Consulting Engineer of the U. S. Bureau of Mines, and Professor of Dynamical Engineering of the University of Pennsylvania, entitled "Producer Gas from Low Grade Fuel." He referred to investigations that have been made by the U. S. Bureau of Mines on the utilization in gas producers of fuels heretofore not regarded as adapted to the economic production of power and discussed the results of same. The many interesting developments that have resulted therefrom were considered in their relation to the elimination of the smoke nuisance, the centralization of power and its development and distribution. The paper was illustrated by lantern slides, and numerous specimens of the low grade fuels investigated were shown. The paper was extensively discussed.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The second regular meeting of the Armour Student Branch was held November 5 and the speakers of the evening were: H. D. Gumpper, whose subject was Fans and Blowers; and L. Bunge, who discussed Safety Devices for Elevators. Both authors were members of the Student Branch. The papers were extremely interesting and well illustrated by lantern slides. Mr. Gumpper dwelt upon the Sirocco fan, showing its superiority over other types, and backing his arguments by tests. Mr. Bunge confined his remarks to safety devices for electric and hydraulic elevators.

CARNEGIE INSTITUTE OF TECHNOLOGY

At a meeting of the Carnegie Mechanical Engineering Society held on November 11, a paper on Helical Reduction Gears was read by C. E. Bates, of the class of 1909. The author dealt entirely with the three processes of Citroen, Wuest and Faucus, and gave in detail the construction of the machines used for cutting the gears by the different processes, and the advantages to be derived from each. In conclusion Mr. Bates compared the merits of helical and spur gears, illustrating his points with data recently obtained from experiments which he performed on reduction gears in the mechanical laboratory of the school. Professors Trinks, Mem.Am.Soc.M.E., and Sprowl entered into the discussion.

COLUMBIA UNIVERSITY

The Mechanical Engineering Society of Columbia University held its first meeting of the year on November 7. The speaker of the evening was R. S. Barnaby, whose subject was Model Aeroplanes. Various types were described and the value of experimenting with models under conditions similar to those met with in actual practice was discussed. The author explained also the greater relative stability of the model over the man-carrying machine, giving illustrations from experiments made by himself. He said that he had met with the best results with models with the elevating plane in front of the main plane, and thought that there was chance for the greatest development along these lines.

CORNELL UNIVERSITY

On November 19 Prof. D. S. Kimball talked on The Relation of the Fine Arts to the Useful Arts. He pointed out the interdependence of the two up to a certain point and from there on, their divergence. He said that every new machine went through a period of subjugation to over decoration, e.g., the modern cash register. Many lantern slides illustrative of the main points were shown.

The Sibley College Student Branch held a meeting on October 22, at which Prof. R. C. Carpenter, Mem.Am.Soc.M.E., spoke of the value of membership in the branch, the duty of the Society to the branches, and the duty of the branches to the Society. Professor McDermott told of his two years' engineering work in Brazil, and Prof. Albert W. Smith, Mem.Am.Soc.M.E., related several anecdotes of early life at Cornell; he also gave an account of the dinner recently given Professor Sweet on the occasion of his 81st birthday.

LEHIGH UNIVERSITY

At the meeting held on November 11 of the Lehigh University Mechanical Engineering Society, E. P. Humphrey spoke on Coal Breakers. After taking up the description of the methods of cleansing coal, Mr. Humphrey entered into a detailed description of the construction of a coal breaker, which he followed by a description of the operation of the breaker. The second speaker of the evening was H. A. Hoffman, flow meter specialist of the General Electric Company, who gave an illustrated lecture on the Flow Meter. The author opened with a brief history of the instrument and then discussed the different types of meters, giving the advantages and disadvantages of each.

LELAND STANFORD JUNIOR UNIVERSITY

On October 28 the Mechanical Engineering Society of Leland Stanford Junior University combined with the Electrical Society to hold a smoker for all members of the two departments of the university, the object of which was to acquaint the underclassmen with the two societies that they might take an interest in them. George M. Brill, Past Manager and Past Vice-President of the Society, was present and spoke a few words to the students.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A meeting of the Mechanical Engineering Society of Massachusetts Institute of Technology was held on November 12, at which C. B. Rowley spoke on Cold Storage Insulation. His paper covered the following points: cork in its growing state, the discovery of the insulation properties of cork, its first use for cold storage insulation, the various forms of cork and the particular application of each, and the construction necessary that each might be employed to its best advantage.

PENNSYLVANIA STATE COLLEGE

At a meeting of the Pennsylvania State College Student Branch held October 17, the speaker of the evening was W. R. Little, whose subject was Fuels for Internal-Combustion Engines.

The second meeting of the year was held on October 22, when excellent

talks were given on the subject of Gasolene as Fuel for Automobiles. Mr. Little, of the class of 1914, presented the opening paper and led the discussion. Professors Moyer and Deimer, Members of the Society, and Messrs. Hall, Foell and Slack too part in the discussion.

POLYTECHNIC INSTITUTE OF BROOKLYN

A meeting of the Polytechnic Institute of Brooklyn Student Branch was held November 1, when G. Harding lectured on The Economic Significance of Fire Waste. He began with the amount of fire waste in the United States for every year, and showed how fire insurance companies endeavored to make good this yearly loss, but how they failed in years of extraordinary disaster. He then pointed out the fact that fire departments only served to stop fire, not to prevent loss, and concluded with a discussion of various methods by which fire waste could be prevented.

PURDUE UNIVERSITY

The opening meeting of the year of Purdue University was held on September 13. Members of the faculty and of the senior class outlined the plans of the Society for the coming year.

At the meeting held on October 14, L. W. Wallace, professor of locomotive and car design, described the tests that had so far been made on the machine erected by the Master Car Builders' Association at Purdue for the determination of the blow dealt on the rail by a loaded car with flat wheels. He also outlined the scope of further tests that are to be run.

The speaker at the third meeting of the year, which was held on October 28, was Professor Peffer of the School of Chemical Engineering. His subject was the Relation of Chemistry to the Mechanical Engineer.

W. E. Starks, of the class of 1914, spoke before the society on the evening of November 11 on Halftone Engraving or Photography. He described the processes in use for the production of halftone pictures and zinc etchings and went into both the photographic and the chemical sides of the subject.

RENSSELAER POLYTECHNIC INSTITUTE

At a meeting held on October 9 at the Rensselaer Polytechnic Institute Student Branch, A. M. Greene, Mem.Am.Soc.M.E., gave an interesting account of his trip abroad with the Society last summer. F. L. Eidman, Stevens Institute 1909, gave a brief account of the founding of the student branch there, and told of the work it had accomplished.

The meeting held October 23 was addressed by C. E. Davies, of the class of 1914, who spoke on the power development of the New York Mills Company, at New York Mills, N. Y. The talk was followed by a discussion upon the details of steam power plant design.

The branch was addressed by W. Kelly at the meeting held on November 6. He gave a very complete account of the life of the late Dr. Diesel. This was followed by a description of the Process of Separation of Magnetite Iron from Its Ores, by H. W. Henry.

STATE UNIVERSITY OF IOWA

The Prevention of Industrial Accidents was the title of an illustrated lecture given by F. H. Guldner before the State University of Iowa on

October 14. The talk was limited to those phases concerning the mechanical engineer; the importance of accident prevention and the methods adopted by large firms in reducing accidents, being especially emphasized.

On November 11, the mechanical and electrical engineering student members, together with the Compass Club, held a joint meeting. Talks were given on the Senior Inspection Trip through Chicago; Gary, Ind.; and Milwaukee, Wis.; the subject being treated from the mechanical, electrical and civil engineers' viewpoint. G. Konvalinka, student member of the Society, represented the mechanical engineers.

STATE UNIVERSITY OF KENTUCKY

A meeting of the State University of Kentucky Student Branch was held on November 3 and Prof. F. Paul Anderson, Mem.Am.Soc.M.E., gave a talk on What is The American Society of Mechanical Engineers. The speaker outlined the future purposes of the Society and what it stood for in the engineering world. In the course of his remarks, he brought to the attention of the members the necessity of a code of ethics for the engineering profession. A. R. Bennett, a student member, followed with a digest of the paper on The Art of Enameling or the Coating of Steel and Iron with Glass, by Raymond F. Nailler, and published in The Journal for October. Methods of treatment and some of the chemistry of the processes were brought out.

UNIVERSITY OF CALIFORNIA

At a meeting held on October 21 of the University of California Student Branch, L. P. Denny read a paper on Scientific Management; and G. H. Briggs, one on Green Economizers, with particular reference to their installation and operation.

At the meeting held November 4 the following papers were given: The Measurement of Steam Flow, by R. Hanson; and Installation and Operation of a Funicular Railway, by L. T. Kennedy. Mr. Kennedy devoted most of his discussion to the difficulties attendant upon the construction, and also the operating devices used.

On November 18 A. C. Moorehead discussed the Gas Engine Carbureter. P. H. Landon gave a talk on the Effect of Moisture in the Intake of a Gas Engine, which was followed by a discussion on the part of the members of the society upon the particular point raised by the paper, namely, whether or not the efficiency of the engine might be increased by the use of moisture with the fuel mixture.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch was addressed on November 11 by H. M. Wood, Mem.Am.Soc.M.E., on Special Machine Operations in the Manufacture of Lathe Parts. The methods of production of the various parts of the lathe made by the Lodge & Shipley Machine Tool Company were explained in detail and illustrated by over fifty lantern slides. Special emphasis was placed on the merits of the longitudinal and diametrical stops of the lathes. A special, independent motor-driven feed lathe for boring lathe spindles and locomotive axles was also discussed in detail. The discussion which followed took the form of questions asked by the audience and answered by Mr. Wood.

UNIVERSITY OF ILLINOIS

Facilities for Handling Work was the title of the paper read by B. W. Benedict, director of Shop Laboratories, at a meeting held on November 7 before the University of Illinois Student Branch.

UNIVERSITY OF KANSAS

At a meeting of the University of Kansas Student Branch on October 30, the date of the Annual Meeting of the section was fixed as December 12, and plans were discussed for the coming meeting.

H. H. Feierebend read an excellent paper on Airships in France, England and Germany. The mechanical features of the various types were described in detail, which was followed by a discussion by those present. H. N. Baugher read a technical report on Ball Compound Engine and Accessories at the University of Kansas. L. C. Angevine gave an extract on the Eastman Kodak Company's plant from a paper published in the American Machinist. It was stated that the plant covered 150 acres, was of 20,000 h.p. capacity, and that as many as 500 miles of moving picture film was manufactured per day. Messrs. H. C. Ackerman, O. T. Potter, H. L. Newby and others discussed the paper.

At the meeting held on November 7 the senior trip to St. Louis and Keokuk was reported. Mr. Berwick gave an interesting report on Ice and Refrigeration, including a brief account of the bi-annual Icemen's Congress and their trip. Mr. Hagenbush reported on Machinery, and Mr. Beauchamp told of the Cedar Rapids hydroelectric development, the difficulties of construction, and some of the mechanical details. He said that the plant was designed for an ultimate capacity of 160,000 h.p., which would be used for the production of aluminum and carborundum products. This report was discussed by Prof. F. H. Sibley, and W. J. Malcolmson, and H. L. Newby. Mr. Cunnick gave some of the humorous experiences of a trouble-shooter from Gas Engine.

UNIVERSITY OF MAINE

The newly organized Student Branch at the University of Maine held a meeting on November 3 for the purpose of electing officers. The following were chosen: Chairman, E. E. Fowler; vice-chairman, W. L. Wark; secretary-treasurer, A. B. Hayes.

UNIVERSITY OF MISSOURI

On Octobr 20 a meeting was held of the University of Missouri Student Branch at which Professor Hibbard, Mem.Am.Soc.M.E., presented a paper on the New Experimental Laboratory, and the Experimental Lathe.

On November 4 Professor Wescot presented a very interesting paper on Concrete.

UNIVERSITY OF MINNESOTA

The first meeting of the newly organized Student Branch at the University of Minnesota was held on November 13 and the following officers were elected to serve until the annual election in January: Chairman, A. Buenger; vice-chairman, M. Ovestrud; secretary, J. A. Colvin; treasurer, J. L. Hartney. The branch already numbers fifteen members.

UNIVERSITY OF WISCONSIN

On October 16 a joint meeting of the student branches of the electrical, civil and mechanical engineers was held at the University of Wisconsin. Illustrated talks were given by Prof. L. S. Smith, of the department of civil engineering, Mr. Disque of the department of electrical engineering, and Professors Thorkelson and Christie of the department of mechanical engineering and members of the Society, on impressions received by them during recent European trips. Professor Smith discussed the matter of roads and pavements in Germany and England; also the plans adopted by European countries for city planning. He compared the methods used there with those of this country and also the results obtained. Both Professor Thorkelson and Mr. Disque gave talks of a more general character, while Professor Christie described various types of engines used in power work. These last three were members of the party of the Society visiting Germany last summer.

YALE UNIVERSITY

On October 24 the Student Branch of Yale University held its first meeting of the year. Twenty-three new members were enrolled and the following were elected to serve on the governing board: H. S. Houston, R. L. Dickey, D. B. Porter. An interesting address was given by Prof. J. W. Roe, Mem.Am.Soc.M.E., on the advantages of membership in the student branch and subsequently in the Society, and on what such membership means to men in the engineering profession.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

1016 Man to take charge of an Indianapolis office of firm of merchant engineers. Dravo-Doyle Company.

1104 Wanted, for woodworking concern: first-class estimator for sash and doors, exterior and interior house finish and trim, able to estimate, make details, write factory orders, and arrange contracts for all kinds of building work; must be a man of ability, integrity, and personality. Salary according to ability. Address Edward F. White, 51 Chestnut Ave., Rutland, Vermont.

1105 Thoroughly practical, hustling shop foreman, experienced in engine and pump work; a thorough mechanic, able to produce the maximum output of highest quality at lowest cost, and familiar with best and latest up-to-date practice. State age, experience, references, and compensation expected. Apply through the Society. Location, Massachusetts.

1106 Man to design a line of small gasolene and crude oil engines; must be more than a mere draftsman experienced in the actual design of engines, preferably of the internal-combustion type; salary not exactly determinate, but probably would not reach $2500 at the start. Apply through Society.

1107 A young man wanted to manage the manufacturing and installation of a new household article that has been thoroughly tried out and perfected. One who is able to furnish a few thousand dollars for half interest.

1108 A moderate sized plant located in the neighborhood of Franklin, Va., manufacturing high-grade steam specialties, desires a factory foreman or superintendent. Must be able to prepare working drawings, a manager of men, a good executive, thorough and energetic, with experience in the use of standard jigs. No foundry experience required. In replying, state salary expected, experience in full, age and references. Apply through the Society.

1109 An engineer, thoroughly experienced in the design and operation of oil engines. Should be familiar with foreign development and practice. State age, experience, compensation. Apply through the Society.

1110 Factory foreman or superintendent, practical machinist, good judge of men, excellent opportunity for an energetic experienced man who can handle 100 men and produce rapidly accurate heavy machine work. Eastern location. Apply through the Society.

1111 Salesman for middle west and to represent direct factory making heavy machinery. Salary $2000 to $2500. Apply through the Society.

1113 Salesman for New York City to represent factory making heavy machinery. Salary $2000 to $2500. Apply through the Society.

1114 Experienced mechanical engineer who in addition to having a thorough technical education and practical knowledge of boilers and engines, has demonstrated executive capacity, initiative, and ability to do business with other men without friction; must be under 35 years of age and preferably hold a responsible position at the present time.

1118 Good engine draftsman for concern manufacturing engines and boilers. New York State.

1119 Plant consisting of machine, boiler, pipe, blacksmith, foundry and pattern shops and employing about 250 men, wants first class superintendent, an American, between thirty and thirty-five years old, good training and experience and thoroughly up to date in shop methods. Previous experience as superintendent of a large plant not essential, provided applicant has proper qualifications for the position and experienced in the handling of men in the works. Western location. Confidential; apply through the Society.

MEN AVAILABLE

330 Member, technical graduate, 31 years of age, desires to secure position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing and purchasing equipment, superintending construction and operating departments; consulting engineering work on large properties, including the investigation of power production and cost reduction for large corporations in connection with the consolidation of isolated plants; experienced in mill and reinforced concrete construction work; at present employed and desires a change for advancement.

331 Sales engineer, experience in handling high-grade specialties in power transmission and machinery lines; known to machinery and supply trade of United States and Canada for past eight years.

332 Mechanical engineer, age 30, graduate Massachusetts Institute of Technology, with four years' experience in large central station, would like superintendency of medium sized light and power station or the generating department in a larger central station; thoroughly familiar with all modern methods of economy in power plant; also sale of electricity.

333 Member, mechanical and electrical engineer, technical graduate, experienced in design, construction and installation of electrical and hydraulic apparatus, desires position with consulting engineer or engineering construction concern. At present employed as works manager of eastern concern making hydraulic apparatus.

334 Junior member, age 31. Eleven years' practical experience in the development, installation and operation of large steam turbine and electrical apparatus. Five years as chief engineer for one of the largest interurban railways in western Pennsylvania. At present employed as assistant electrical engineer in large industrial proposition. Well informed, good address and appearance. Thorough operating and commercial training. Desires position as chief engineer of power stations with interurban railway or light and power company in middle states or middle west. Salary $2000-$3000.

335 Member desires position as works manager, superintendent or engineer; competent to organize all departments of manufacturing plant along modern lines; long experience, best references; expert on developing new inventions.

336 Junior member, age 30, experienced in design, construction and superintendence of high and low-tension substations, transmission lines, etc., desires connection with large contracting firm or manufacturing plant requiring services of graduate mechanical and electrical engineer. Best references, moderate salary.

337 Member, technical graduate, age 40. Locomotive shop, steel works and general construction experience. Inspection of rails, structural material and galvanized product, desires position as inspection engineer.

338 Member, graduate mechanical engineer, ten years' experience in designing and manufacturing gas, gasoline and oil engines and all modification; special study of tractors for agricultural purposes; can design and build a tractor that will make a profit for the manufacturer and purchaser. At present employed. Location, middle west preferred. Salary $3000.

339 Mechanical and electrical engineer, member, 35 years of age, technical graduate, with about 15 years' experience in mechanical and electrical work, as power plant, design, construction, and operation, electrical equipment of manufacturing plants, heavy mechanical machine design and construction, sub-station and street railway work, and reports on hydro-electric development.

340 Member; now employed, with wide experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, desires permanent position in New York City; salary to start $4000. Graduate Massachusetts Institute of Technology in mechanical engineering, post graduate course in electrical engineering.

341 Stevens Institute of Technology graduate, mechanical engineer, wishes position as assistant to plant or efficiency engineer or works manager. At present employed, desires a change and an opportunity to make good, and responsibility will be the reward for conscientious work. Future considered before salary.

342 General utility executive, technically educated as a mechanical engineer, who, under the titles of assistant vice-president and secretary, has served as a general utility man for well-known manufacturers of machinery; duties including sales, advertising, development of new ideas,

pushing out work and general office management; seeks a responsible position where a wide engineering knowledge will be of value.

343 Mechanical engineer, technical graduate, 31, desires executive position. Ten years' experience in the determination and control of manufacturing operation costs, power plant and general plant engineering; well fitted for production engineer or assistant superintendent of large plant where results will be appreciated.

344 Junior member, at present employed as mechanical engineer and estimator with large boiler company, desires responsible position with growing concern offering better opportunities; ten years' experience as draftsman, designer, estimator, purchasing agent and assistant manager, familiar with all branches of boiler manufacture and general plate work.

345 Sales manager, exceptional experience in design and selling power plant and other machinery, as well as construction and installation, fitted by thoroughly practical and technical training to direct manufacture and sale of product. Specially good at getting results from branch offices and salesmen. Valuable acquaintance gained by 15 years' successful selling in territory east of and including Pittsburgh and Buffalo. Cornell graduate.

346 Member, 36 years of age, graduate mechanical engineer, 15 years' broad and general experience in designing, estimating and constructing various types of mill buildings, factories, railway shops and power stations; thoroughly familiar with all kinds of building construction. At present employed as superintendent on a contract job.

347 Recent Columbia University graduate wishes to connect with a large industrial concern or an industrial engineering firm where there is a future for a hard, energetic worker; willing to start in any position; location immaterial; best references. Address Mechanical Engineer, 74 West 92d Street, New York City.

348 Member, college graduate with degree of M.M.E., served as machinist before entering college, 15 years' experience in charge of shops and building and operating steam and water power plants; at present chief engineer of an electric railway system, but desires a change. Specially qualified as a designing engineer.

349 Member, age 42, desires position as assistant manager or general superintendent; practical mechanic, wide experience in office, stores and shop in the manufacture of internal-combustion engines, stationary and tractor, marine engines, pumps, mining machinery, steam and locomotive work, electrical apparatus. Design and erection shop and foundry buildings, steam, electric, pneumatic and hydraulic power plants. Competent to assume full charge.

NECROLOGY

JAMES RICHARD BELL

James R. Bell, who died at his home in Hazeldene, Ightham, Kent, England, on July 14, 1913, was born on August 21, 1841, in Wick, Scotland, in the house of his grandfather, James Brenner, a famous engineer. Mr. Bell was educated at the Aberdeen Gymnasium, and served his apprenticeship with the Gardiners in London. His early work was on various surveys in England and Wales and on the construction of the Cairo Ramelah Railway.

In 1868 he went to India, being connected first with the irrigation department in the Madras Presidency, and in April 1870, was transferred to the state railways directly controlled by the Government of India, where he remained until his retirement in 1896.

Mr. Bell's most important work in India was in connection with the building of railways and bridges, and he devised many novel means for the training and improvement of diluvial rivers, on which he was a recognized authority. Among his achievements are the Empress Bridge over the Sutlej River, the Aneroati Railway, the railway to Hyderabad, Deccan, the Jumna Bridge, near Mutra, an important bridge over the Sutlej at Ferozepore, and a bridge over the Chenab River at Sher Shah, near Multan. Mr. Bell also investigated the bridging of the Indus at Sukkur, where a steam train ferry had been provided for the Indus Valley State Railway, and over which Mr. F. E. Robertson subsequently constructed the cantilever structure now standing.

In 1891 Mr. Bell became consulting engineer to the Government of India for state railways, receiving a permanent appointment to this position in 1894, which he held until his retirement in 1896.

On his retirement Mr. Bell was still in excellent health and he practised as a consulting engineer. He is said to have been the original of Findlayson in Kipling's "Bridgebuilders," and

was regarded by his contemporaries in India as an engineer of extraordinary attainment, though his services were never more than formally acknowledged and never adequately honored by his government. Apart from the successful and very rapid construction of several fine railway bridges and the evolution of the only proper and scientific method of controlling the flow of itinerant rivers when bridged, he deserved the most substantial recognition of his work on the Ruk-Sibi Railway during the Afghan War, not only because through the exercise of marvellous organizing and directing capacity he performed almost a miracle in railway construction, but because he provided possibly the only means of ending a critical situation in Afghanistan.

WILLIAM GEORGE CHAMBERS

William George Chambers, chief engineer of the National Cash Register Company, Dayton, Ohio, died in New York on May 1, 1913.

Mr. Chambers was born at Belleville, Ontario, on April 2, 1874, and on completion of his education in the public schools, served his apprenticeship with the Bagley & Sewall Company, Watertown, N. Y. In 1900 he entered the employ of the National Cash Register Company as a model-maker in one of the inventions departments. The following year he won promotion and became foreman of one of the assembling departments. In 1905 he was sent to Canada as superintendent of the company's factory at Toronto, returning the following year as foreman of another assembling department. Two years later he was made supervisor of the entire assembling division and in 1910 became assistant general superintendent. When the important position of chief engineer of the company was created in 1912, Mr. Chambers was named to fill the place, becoming responsible for the ordering of all changes and improvements in registers, the quality of the material used, and all the inspection, tool designing and toolmaking of the firm.

RUDOLPH DIESEL

The recent death of Dr. Rudolph Diesel is a severe loss to the engineering profession at large, as well as to the many personal friends of the distinguished engineer. Dr. Diesel, who had been spending a week-end at Ghent with M. Carels of Carels Frères, sailed from Antwerp in company with M. Carels and M. Luckmann,

chief engineer of the firm, on the evening of September 29, with the intention of attending the annual meeting of the Consolidated Diesel Engine Manufacturers, Ltd., in London. Upon arrival in Harwich next morning, it was discovered that Dr. Diesel was missing, having apparently fallen overboard during the voyage. Some days later his body was recovered, thus confirming the fears of his family and friends.

Dr. Diesel's career has been one of interest from the first. In the early eighties of the last century, as a student in the Technical High School of Munich, while listening to a lecture on thermodynamics by the famous Professor Linde, he jotted down in his notebook these words: "See if it would not be possible to realize practically the isothermal." It was only a carelessly scribbled line, but in it was the germ of a great idea, which in the mind of a man peculiarly fitted to "see" was destined to develop a dozen years later, into what may be justly considered as one of the most important achievements of mechanical engineering of the last century, the Diesel engine.

Rudolph Diesel was born in 1858, the son of a German family residing in Paris. In 1870 changed political conditions forced his father to move to London and to send the boy to Augsburg, Germany, the very place where, twenty-three years later, the first Diesel engine was placed on the testing stand, to be greeted at first with incredulity and then with the unstinted applause of the engineering world. The boy's youth was spent, in the methodical German fashion, in years of high school training and thorough drilling in engineering fundamentals under the competent supervision of men like Schroeter and Linde, interrupted from time to time by long visits to London where his father was still making his home and where he acquired that mastery of the English language which was such a pleasure to his many friends in this country.

From the beginning Diesel was kept in close touch with the problems of thermodynamics, first as assistant to Linde in his work at the Munich Technical High School, and later as his technical representative in connection with the manufacture of the Linde refrigerating machinery, then at its beginning. These studies resulted in Diesel's taking out a patent for a new engine in the early nineties, and in his publishing a book under the title, "The Theory and Construction of a Rational Heat Engine." The rational engine was based on a principle so simple that very few consented to believe in its truth, viz., that pure air could be compressed to so high a point

that the fuel injected into it would ignite and burn. Happily for Diesel, however, there were a few men like his former teacher Professor Schroeter, of Munich, and Professor Hartmann, of Charlottenburg, who expressed their belief that the engine would work on the new cycle, and their opinion was powerful enough to induce the largest two machine construction companies in Germany, the Krupp works and the Augsburg-Nuremberg Company, to unite in an effort to test out the invention.

Two years of trial followed. The first engine blew up as soon as fuel was injected, nearly killing Diesel himself. Alterations were made, an air supply pump for the injection of fuel added, but the engine would not run and was always a source of danger. "I myself," said Diesel in his talk before the Society in 1912, "would never have had the patience and the courage to continue the work after the disappointments of the first two years of experimenting, had I not been supported by an unalterable belief in the correctness of my mathematical deductions."

Finally, after four years of laborious experimenting, the correctness of mathematical deductions,—the true beacon of all engineering work,—was vindicated in the form of an engine working on an entirely new principle, with a thermodynamic economy practically not yet exceeded. From 1897 the name Diesel became attached to a new prime mover which has since been built in thousands of units.

The vindication of the principle of the Diesel engine led to a strenuous effort to promote its introduction into all fields where it could be used. The development of the horizontal engine, the marine Diesel engine, the high-speed engine for driving dynamos, and finally the Diesel engine locomotive with direct drive and electric transmission are matters of history, and it is to be noted with profound regret that the inventor's returns were by no means commensurate with the services he rendered to humanity.

The members of the Society who visited Dr. Diesel at his delightful home in Munich during the past summer were enabled to renew the acquaintanceship formed during Dr. Diesel's tour of America in 1912, when he spoke before the Society of his own work. It is seldom that one has so endeared himself to the members generally as did Dr. Diesel, and his death is a personal loss to the membership of the Society.

ARTHUR J. FRITH

Arthur J. Frith was born at Philadelphia, Pa., February 23, 1852, and died at Chicago, Ill., November 10, 1913, of acute dilation of the heart. Mr. Frith was educated at Georgetown College, Georgetown, D. C., and at the Rensselaer Polytechnic Institute, where he was graduated in 1873 with the degree of civil engineer.

As a young man Mr. Frith worked in steel and rolling mills and was sent to England for special information in regard to steel manufacture. He taught at Lehigh University; was assistant chief engineer in connection with the Mississippi River Commission on Government work; designer for the Newark Machine Tool Works, the C. W. Hunt Company, and engineer on coal-handling plants with the Trenton Iron Company; assistant chief engineer and designer with the Diesel Motor Company of America in 1898; secretary of the Washington Company, contractors, New York; and consulting engineer, New York. Latterly he was associate professor of mechanical engineering at Armour Institute of Technology, specializing in thermodynamics, gas and oil engines, compressed air and refrigeration. He was the author of a number of technical papers, the owner of various patents, and had done special research work on boiler efficiency, gas engine efficiency, regenerator efficiency, etc.

He was an engineer in the best sense, a lover of truth, very careful in considering the different aspects of a problem, giving each due weight, and deciding each point after intensive study. He truly sank himself in his work, and presented his final conclusions with such modesty and amiability that a casual observer might easily have failed to realize the conscientious work and clear insight which prompted the conclusion. In the early work of the introduction of the Diesel motor into this country, these qualities of mind and the thoroughness of his equipment in mathematics and thermodynamics were of inestimable value; and were gratefully acknowledged by the late Dr. Diesel. His domestic life was for years a very happy one. His wife was a lady of many pleasant accomplishments, and a cheerful disposition, which enabled them to accept the ups and downs of an engineer's life with a noble equanimity. They had one child, a boy of rare promise, who combined the fine qualities of both parents. In his eleventh year he was run over by an automobile and instantly killed in

the presence of his father, whose side he had left but an instant before. This was no doubt the cause of our friend's early death, to which the physician gives a technical name. E. D. Meier.

LUDWIG HERMAN

Ludwig Herman was born in Prague, December 2, 1842, and died in Cleveland, Ohio, on October 21, 1913. He received his education at the University of Prague and in the machine shops of Vienna. In 1865 he came to America, residing first in New York, where he was employed by the Brush Electric Light Company and the Yale & Towne Manufacturing Company, and later in Chicago, where he became an engineer for the Rust Bridge Company. He was for several years chief engineer of the Detroit Bridge & Iron Works Company, in Detroit, Mich., and later became a member of the firm of the Fox & Hower Bridge Company of Chicago, designing and building numerous bridges all over the country, among them that over the Mississippi River at Hannibal, Mo., one of the largest bridges of its time. In 1885 Mr. Herman became general manager and engineer of the Buckeye Machine Company of Cleveland, Ohio.

Mr. Herman designed the first 20,000 candle power arc lamp for the Paris Exposition, and lowered the first electric light mast in 1885 at Akron, Ohio. He planned and executed the structural iron work of the tower of the Fairmount Street reservoir and executed the structural iron work for the additional stories and roof of the old court house of Cleveland.

He was a member of the Cleveland Engineering Society.

OFFICERS AND COUNCIL

President

W. F. M. Goss

Vice-Presidents

Terms expire 1913

Wm. F. Durand
Ira N. Hollis
Thos. B. Stearns

Terms expire 1914

James Hartness
I. E. Moultrop
H. G. Stott

Managers

Terms expire 1913

D. F. Crawford
Stanley G. Flagg, Jr.
E. B. Katte

Terms expire 1914

Chas. J. Davidson
Henry Hess
Geo. A. Orrok

Terms expire 1915

W. B. Jackson
H. M. Leland
Alfred Noble

Past-Presidents

Members of the Council for 1913

M. L. Holman
Jesse M. Smith
Alex. C. Humphreys
George Westinghouse
E. D. Meier

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

F. R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

W. F. M. Goss, *Chmn.*
Alex. C. Humphreys, *V-Chmn.*
E. B. Katte
E. D. Meier
Geo. A. Orrok
H. G. Stott

STANDING COMMITTEES

Finance

R. M. Dixon (1), *Chmn.*
W. H. Marshall (2)
H. L. Doherty (3)
W. L. Saunders (4)
W. D. Sargent (5)

Meetings

H. de B. Parsons (1), *Chmn.*
L. P. Alford (2)
H. E. Longwell (3)
H. L. Gantt (4)
R. H. Fernald (5)

Publication

G. I. Rockwood (1) *Chmn.*
G. M. Basford (2)
C. I. Earll (3)
I. E. Moultrop (4)
F. R. Low (5)

Membership

Hosea Webster (1), *Chmn.*
Theodore Stebbins (2)
W. H. Boehm (3)
H. C. Meyer, Jr. (4)
L. R. Pomeroy (5)

Library

L. Waldo (4), *Chmn.*
C. L. Clarke (1)
Alfred Noble (2)
W. M. McFarland (3)
The Secretary

Research

R. H. Rice (4), *Chmn.*
L. S. Marks (1)
A. L. De Leeuw (2)
Rolla C. Carpenter (3)
R. D. Mershon (5)

House

E. Van Winkle (1), *Chmn.*
H. R. Cobleigh (2)
S. D. Collett (3)
W. N. Dickinson (4)
F. A. Scheffler (5)

Public Relations

J. M. Dodge (3), *Chmn.*
J. W. Lieb, Jr. (1)
F. J. Miller (2)
W. R. Warner (4)
G. M. Brill (5)

SOCIETY REPRESENTATIVES

Engineering Education

A. C. Humphreys
F. W. Taylor

General Conference Committee of National Engineering Societies

C. W. Baker
E. D. Meier

Council of A. A. A. S

A. C. Humphreys
W. B. Jackson

John Fritz Medal

H. R. Towne (1)
J. A. Brashear (2)
F. R. Hutton (3)
J. R. Freeman (4)

Trustees U. E. S.

A. C. Humphreys (1)
F. J. Miller (2)
Jesse M. Smith (3)

SPECIAL COMMITTEES

Research Committee, Sub-Committee on Steam

R. H. Rice, *Chmn.*
C. J. Bacon
E. J. Berg
W. D. Ennis
L. S. Marks
J. F. M. Patitz

Power Tests

G. H. Barrus, *Chmn.*
E. T. Adams
L. P. Breckenridge
D. S. Jacobus
William Kent
E. F. Miller
Arthur West
A. C. Wood

Pipe Thread Gages

E. D. Meier, *Chmn.*
George M. Bond
A. M. Houser
J. C. Meloon
Chas. A. Olson
Peter C. Patterson
Henry G. Stott

Student Branches

F. R. Hutton, *Chmn.*
Wm. Kent
Geo. A. Orrok

Research Committee. Sub-Committee on Materials of Electrical Engineering

R. D. Mershon

Note—Numbers in parentheses indicate number of years the member has yet to serve.

SPECIAL COMMITTEES—*Continued*

Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for Care of Same in Service

J. A. Stevens, *Chmn.*
W. H. Boehm
R. C. Carpenter
Richard Hammond
C. L. Huston
H. C. Meinholtz
E. F. Miller

Tolerances in Screw Thread Fits

L. D. Burlingame, *Chmn.*
Elwood Burdsall
F. G. Coburn
F. H. Colvin
A. A. Fuller
James Hartness
H. M. Leland
W. R. Porter
F. O. Wells

Conference Committee on Engineering Standards

H. G. Stott, *Chmn.*
A. F. Ganz
Carl Schwartz

Society History

J. E. Sweet, *Chmn.*
F. R. Hutton, *Secy.*
H. H. Suplee

Committee on International Engineering Congress 1915

The President
The Secretary
W. F. Durand
R. S. Moore
T. W. Ransom
C. R. Weymouth

Pipe Threads

E. M. Herr, *Chmn.*
W. J. Baldwin
G. M. Bond
S. G. Flagg, Jr.

L. V. Benet, *Paris Rep.*

Flanges

H. G. Stott, *Chmn.*
A. C. Ashton
A. R. Baylis
W. M. McFarland
Wm. Schwanhausser
J. P. Sparrow

Committee on Bureau of Information Respecting Engineering Standards in all Countries

Henry Hess, *Chmn.*
J. H. Barr
Charles Day
C. J. Davidson
Carl Schwartz

Research Committee. Sub-Committee on Safety Valves

P. G. Darling, *Chmn.*
H. D. Gordon
E. F. Miller
F. L. Pryor
F. M. Whyte

Committee on National Museum

E. D. Meier, *Chmn.*
G. F. Kunz
George Mesta
H. G. Reist
Ambrose Swasey

Standard Cross-Section Symbols

H. deB. Parsons, *Chmn.*
F. deR. Furman
A. E. Norton
Bradley Stoughton
John W. Upp

Changes in the Patent Laws of U. S

W. H. Blauvelt
Carl Thomas
B. F. Wood
Edward Weston
W. E. Winship

Code of Ethics

C. W. Baker, *Chmn.*
C. T. Main
E. D. Meier
Spencer Miller
C. R. Richards

Refrigeration

D. S. Jacobus, *Chmn.*
P. De C. Ball
E. F. Miller
A. P. Trautwein
G. T. Voorhees

Standardization of Filters

G. W. Fuller, *Chmn.*
Jas. C. Boyd
P. N. Engel
J. C. W. Greth
Wm. Schwanhausser

Conservation

G. F. Swain, *Chmn.*
C. W. Baker
L. D. Burlingame
M. L. Holman
Calvin W. Rice

Standardization of Catalogues

Wm. Kent, *Chmn.*
J. R. Bibbins
M. L. Cooke
W. B. Snow

Chairmen of Sub-Committees of Committee on Increase of Membership

Atlanta, Park A. Dallis
Boston, A. L. Williston
Buffalo, W. H. Carrier
Chicago, Fay Woodmansee
Cincinnati, J. T. Faig
Michigan, H. W. Alden
New York, J. A. Kinkead
Philadelphia, T. C. McBride
St. Louis, John Hunter
St. Paul, Max Toltz
San Francisco, Thomas Morrin
Seattle, R. M. Dyer
Troy, A. E. Cluett

Increase of Membership

I. E. Moultrop, *Chmn.*
F. H. Colvin
H. V. O. Coes
J. V. V. Colwell
R. M. Dixon
W. R. Dunn
J. P. Ilsley
E. B. Katte
R. B. Sheridan
H. Struckmann

SUB-COMMITTEES OF THE COMMITTEE ON MEETINGS

Cement Manufacture

J. G. Bergquist, *Chmn.*
H. J. Seaman, *V-Chmn.*
G. S. Brown
W. R. Dunn
F. W. Kelley
Morris Kind
F. H. Lewis
W. H. Mason
R. K. Meade
Ejnar Posselt
H. Struckmann
A. C. Tagge
P. H. Wilson

Machine Shop Practice

F. H. Colvin, *Chmn.*
E. P. Bullard
L. D. Burlingame
W. L. Clark
A. L. DeLeeuw
W. H. Diefendorf
F. L. Eberhardt
F. A. Errington
A. A. Fuller
H. D. Gordon
H. K. Hathaway
E. J. Kearney
Wm. Lodge
F. E. Rogers
N. E. Zusi

Textiles

C. T. Plunkett, *Chmn.*
E. W. Thomas, *Secy.*
D. M. Bates
John Eccles
E. D. France
E. F. Greene
F. W. Hobbs
C. R. Makepeace
C. H. Manning
H. F. Mansfield

Iron and Steel

Jos. Morgan, *Chmn.*
Thos. Towne, *Secy.*
W. P. Barba
F. F. Beall
Rogers Birnie
A. L. Colby
Julian Kennedy
M. T. Lothrop
W. E. Snyder
J. T. Wallis
R. M. Watt

Depreciation and Obsolescence

Alex. C. Humphreys, *Chmn.*
J. G. Bergquist
C. J Davidson
A. E. Forstall
F. W. Kelley
H. Struckmann

Air Machinery

F. W. O'Neil, *Chmn.*
H. V. Conrad
William Prellwitz
R. H. Rice

Administration

J. M. Dodge, *Chmn.*
L. P. Alford, *Secy.*
D. M. Bates
John Calder
H. A. Evans
James Hartness
W. B. Tardy
Alexander Taylor
H. H. Vaughan

Industrial Building

F. A. Waldron, *Chmn.*
H. A. Burnham
Charles Day
William Dalton
J. O. DeWolf
C. T. Main

Railroads

E. B. Katte, *Chmn*
G. M. Basford
W. G. Besler
A. H. Ehle
T. N. Ely
W. F. M. Goss
A. L. Humphreys
W. F. Kiesel
W. B. Potter
N. W. Storer
H. H. Vaughan
R. V. Wright

Fire Protection

J. R. Freeman, *Chmn.*
E. V. French, *V-Chmn.*
Albert Blauvelt
F. M. Griswold
H. F. J. Porter
T. W. Ransom
I. H. Woolson

Hoisting and Conveying

R. B. Sheridan, *Chmn.*
C. K. Baldwin
Alex. C. Brown
O. G. Dale
P. J. Fickinger
F. E. Hulett
Spencer Miller
A. L. Roberts
Harry Sawyer

GEOGRAPHICAL SECTIONS OF THE SOCIETY

Milwaukee

Fred H. Dorner, *Chmn*
M. A. Beck
Arthur Simon
Henry Weickel
E. P. Worden

Cincinnati

A. L. DeLeeuw, *Chmn.*
Jas. B. Stanwood, *V-Chmn.*
J. T. Faig, *Secy.*
W. G. Franz
G. W. Galbraith

Atlanta

J. S. Coon, *Chmn.*
Park A. Dallis, *Secy.*
George Hillyer, Jr.
Cecil P. Poole
Earl F. Scott

St. Louis

E. L. Ohle, *Chmn.*
F. E. Bausch, *Secy.*
F. N. Jewett
John Hunter
L. C. Nordmeyer

San Francisco

A. M. Hunt, *Chmn.*
T. W. Ransom, *Secy.*
W. F. Durand
E. C. Jones
Thos. Morrin

Chicago

Paul P. Bird, *Chmn*
C. W. Naylor, *Secy.*
C. R. Birdsey
W. B. Jackson
A. W. Moseley

Minneapolis-St. Paul

Max Toltz, *Chmn.*
C. L. Pillsbury, *V-Chmn.*
E. J. Heinen

LOCAL MEETINGS OF THE SOCIETY

Boston

Henry Bartlett, *Chmn.*
R. E. Curtis, *Secy.*
H. N. Dawes
W. G. Snow
A. L. Williston

New York

F. A. Waldron, *Chmn.*
Edward Van Winkle, *Secy.*
R. V. Wright, *Treas.*
H. R. Cobleigh
J. J. Swan

Philadelphia

R. D. Yarnall, *Chmn.*
W. R. Jones, *Secy.*
J. E. Gibson
Lewis H. Kenney
T. C. McBride

New Haven

E. S. Cooley, *Chmn.*
E. H. Lockwood, *Secy.*
F. L. Bigelow
L. P. Breckenridge
H. B. Sargent

OFFICERS OF THE GAS POWER SECTION

Chairman

F. R. Hutton

Secretary

Geo. A. Orrok

Gas Power Executive Committee

C. H. Benjamin (1)
W. H. Blauvelt (3)
W. D. Ennis (5)
H. J. K. Freyn (1)
F. R. Low (2)
I. E. Moultrop (4)
H. H. Suplee (1)

Gas Power Literature Committee

R. B. Bloemeke, *Chmn.*
A. W. H. Griepe
W. F. Monaghan
W. S. Morrison
S. I. Oesterreicher
H. G. Wolfe

Gas Power Membership Committee

A. F. Stillman, *Chmn.*
H. V. O. Coes
J. H. Lawrence
F. S. King
J. H. Norris
G. M. S. Tait
J. D. Shaw
H. W. Anderson
C. D. Smith

Gas Power Committee on Meetings

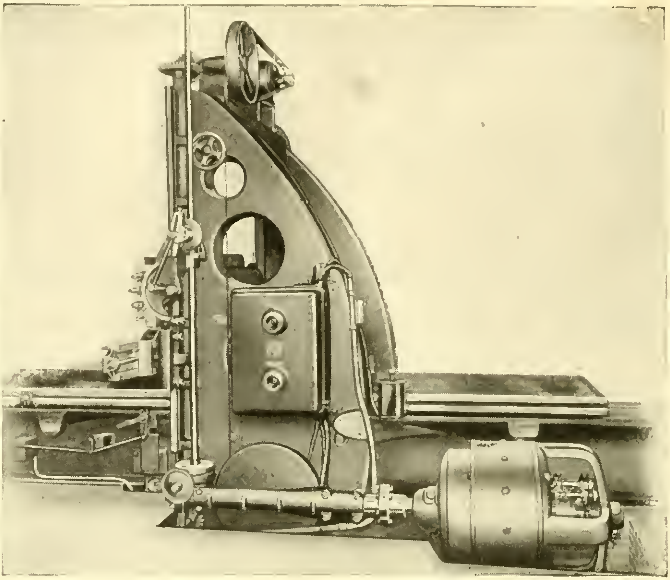
Wm. T. Magruder, *Chmn.*
W. H. Blauvelt
E. D. Dreyfus
A. H. Goldingham
Nisbet Latta
H. B. MacFarland

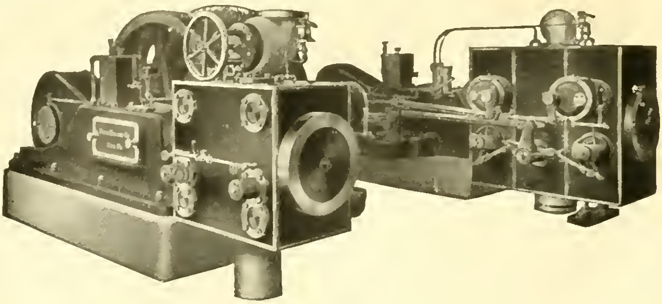
OFFICERS OF AFFILIATED SOCIETY

Providence Association of Mechanical Engineers

W. H. Paine, *Vice-Pres.*
A. H. Whatley, *Treas.*
J. A. Brooks, *Secy.*

Note—Numbers in parentheses indicate number of years the member has yet to serve.





BALL CORLISS ENGINE

With Non-Detaching Valve Gear

It was the drop cut-off gear which made the Corliss Engine successful and economical for slow speeds.

The feature which distinguishes our High and Medium Speed Engines and makes them superior to all other four-valve engines is our *patented non-detaching valve gear*.

This gear by positive action gives the valves the *same movement* that the *drop cut-off* of the slow speed Corliss *produces* by picking up and dropping them.

The valve gear opens and closes the valves at the *proper* time, and holds the valves *absolutely still* during over *half a revolution*.

The valves are given the movement necessary for the *greatest durability* and *tightness*, and the *best form* of valve is made possible.

This engine marks the extreme limit of excellence so far reached in economy and quiet running.

BALL ENGINE CO., Erie, Penn.

The Improved

Murphy Automatic Furnace

We have built this furnace for over thirty years, improving it wherever possible and sparing no effort nor expense to make it as nearly perfect as can be produced.

The largest plant in the world devoted exclusively to the manufacture of Automatic Furnaces.

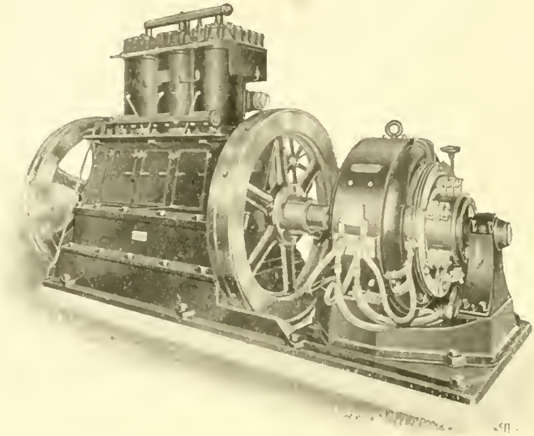
We will be pleased to send full details and description on application

MURPHY IRON WORKS, Detroit, Mich.

FOUNDED 1878 INCORPORATED 1904

THE NASH ENGINE

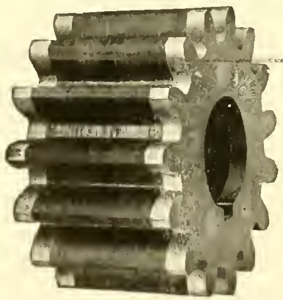
ILLUMINATING NATURAL OR PRODUCER GAS.
IS THE MOST RELIABLE AND ECONOMICAL.



NATIONAL METER COMPANY

CHICAGO NEW YORK BOSTON

ANOTHER ELOQUENT ARGUMENT FOR NEW PROCESS NOISELESS PINIONS



The Editor of the Iron Age says under the heading "Noise and Money Loss in Factories":

*Many users of machinery have awakened to the fact that their manufacturing rooms should be as quiet as possible and in selecting new equipment have had this in mind. * * * * Belts and gearing and other parts of the mechanism need not add to the necessary noises until there is a bedlam of unpleasant vibration.*

New Process Pinions are quiet at high speeds and quiet at low speeds, regardless of load or age.

Used in accordance with our instructions, they do the work of metal pinions but do it quietly, without attention, without power loss and without vibration.

Try one on that noisy drive near the office and you will quickly appreciate the bettered working conditions.

Ask for our book "Noiseless Gear Driving."

N.P.R.H. Co. REG U S PAT OFF

NEW PROCESS IS TO ALL OTHER RAWHIDE AS STEEL IS TO IRON

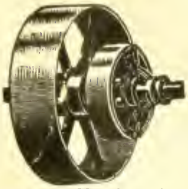
NEW PROCESS GEAR CORPORATION

SYRACUSE, N. Y.

Canadian Agents: Robert Gardner & Son, Ltd., Montreal.

82

THE A. & F. BROWN CO.



Friction Clutch Pulleys and Couplings

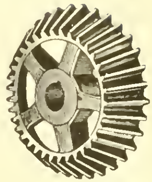
ENGINEERS, FOUNDERS, MACHINISTS AND MILLWRIGHTS

POWER TRANSMISSION MACHINERY

DESIGNED, FURNISHED AND ERECTED

SPECIAL MACHINERY

IRON CASTINGS



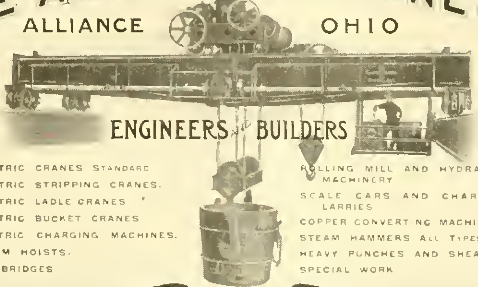
Gears of all kinds and sizes

WORKS: ELIZABETHPORT NEW JERSEY

SALES ROOM: 79 BARCLAY ST. NEW YORK CITY

THE ALLIANCE MACHINE CO.

ALLIANCE OHIO



ELECTRIC CRANES STANDARD
ELECTRIC STRIPPING CRANES.
ELECTRIC LADLE CRANES
ELECTRIC BUCKET CRANES
ELECTRIC CHARGING MACHINES.
I-BEAM HOISTS.
ORE BRIDGES

ROLLING MILL AND HYDRAULIC MACHINERY
SCALE CARS AND CHARGING LARRIES
COPPER CONVERTING MACHINERY
STEAM HAMMERS ALL TYPES
HEAVY PUNCHES AND SHEARS
SPECIAL WORK

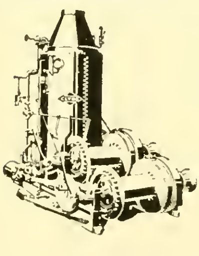
Power Transmission Appliances

FRICTION CLUTCH PULLEYS	FLOOR STANDS
FRICTION CLUTCH COUPLINGS	HEAVY MILL BEARINGS
FRICTION CLUTCH QUILLS	SHAFT COUPLINGS
FRICTION CLUTCH OPERATORS	SHEAVES AND TENSION CARRIAGES
FRICTION CLUTCH SHEAVES	PULLEYS AND FLY WHEELS

FALLS CLUTCH and MACHINERY CO.

CUYAHOGA FALLS, OHIO, U. S. A.

NEW YORK CITY, 206 Fulton St. BOSTON, 54 Purchase St. CINCINNATI, 208 Elm St.



This is the hoist with standardized steel gears and perfect valve mechanism!

Let us send you complete Catalog 33

CLYDE IRON WORKS

DULUTH, MINN., U. S. A.

"You'll find a repeat-order built into every hoist of Clyde-Grade"

MACHINE SHOP EQUIPMENT

FOUNDRY EQUIPMENT

BLOWERS, FANS, DRYERS, ETC.

P. H. & F. M. ROOTS CO.

CONNERSVILLE, IND.

Positive Pressure Blowers for foundries. High Pressure Blowers. Blowers for vacuum cleaning, for laundries, for blacksmiths. Positive Rotary Pumps. Positive Pressure Gas Exhausters. High Pressure Gas Pumps. Flexible Couplings.

BLOWERS
GAS EXHAUSTERS
PUMPS

RUGGLES-COLES ENGINEERING CO.

McCormick Bldg., CHICAGO   Hudson Terminal, NEW YORK

Dryers. Direct heat, Indirect heat, and Steam Dryers for all kinds of materials.

DRYERS

B. F. STURTEVANT COMPANY

HYDE PARK, MASS.

We make equipment to force or exhaust air under all conditions. Largest standard line of "ready to deliver" Fans in the world and special work done where necessary. Consulting representatives in or near your city.

FANS
BLOWERS
ECONOMIZERS
ENGINES

PAPERS PUBLISHED BY A. S. M. E.

No. 1320. Commercial Application of the Turbine Turbo-Compressors: R. H. Rice, price, $0.30; No. 830. Compression and Liquidification of Gas: A. L. Rice, price $0.10; No. 804. A Pneumatic Despatch-tube System for Rapid Transportation of Mails in Cities: B. C. Batcheller, price $0.30; No. 1295. The Development of the Air Brake: (Presidential Address) G. Westinghouse, price $0.20.

PAPERS ON AIR COMPRESSORS AND PNEUMATIC TOOLS

STEEL WORKS AND ROLLING MILL EQUIPMENT

MACKINTOSH, HEMPHILL & CO.

PITTSBURGH, PA.

Engines, single and compound, Corliss reversing and blowing. Rolling Mill and Hydraulic Machinery of all kinds. Shears, Punches, Saws, Coping Machines.

ENGINES
ROLLING MILL MACHINERY

MESTA MACHINE CO.

PITTSBURGH, PA.

WORKS: Mesta Station, P. R. R., W. Homestead, Pa.

Blowing Engines; Rolling Mills; Pickling Machines; Shears; Forging Presses; Gas and Steam Engines; Condensers; Air Compressors; Power Transmission Machinery; Steel Castings; Chilled, Sand and Steel Rolls.

STEEL WORKS AND ROLLING MILL EQUIPMENT

PUMPS AND HYDRAULIC TURBINES

STEAM BOILERS AND ENGINES

FEED-WATER HEATERS

ERIE CITY IRON WORKS

ERIE, PA.

Boilers, water tube, horizontal tubular, return tubular, water bottom portable, open bottom portable, vertical tubular and vertical water tube. Engines: Erie City "Lentz," four valve, enclosed high speed, automatic, center crank, side crank, portable and Feed-Water Heaters from 25 to 600 h.p.

STEAM ENGINES

HARRISBURG FOUNDRY & MACHINE WORKS

HARRISBURG, PA.

Manufacturers of Fleming-Harrisburg Horizontal Engines, Corliss and Single Valve, Simple, Tandem and Cross Compound.

ENGINES

PUMPS

COMPRESSORS

CASTINGS

THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO

Manufacturers of Hamilton Corliss Engines, Hamilton High Speed Corliss Engines, High Duty Pumping Engines, Power Pumps and Compressors, Special Heavy Castings.

BOILERS

E. KEELER COMPANY

WILLIAMSPORT, PA.

Water Tube, Internal Furnace and Return Tubular Boilers. Self-Supporting Stacks, Feed Water Heaters.

ENGINES

REFRIGERATING MACHINERY

THE VILTER MFG. CO.

1070-1088 CLINTON ST. — MILWAUKEE, WIS.

Established 1867

Builders of Corliss Engines, Girder or Heavy Duty Type Bed for Belted or Direct-Connected Service, medium or high speed. Ice and Refrigeration Machines.

BLAST FURNACE

BLOWING ENGINES

WEIMER MACHINE WORKS COMPANY

LEBANON, PA.

Builders of Blast Furnace Blowing engines and equipments. Cinder and hot metal cars. Furnace Bells and Hoppers. Rolling Mill castings. Special attention paid to quick repair work and work governed by Engineers' specifications.

PAPERS ON POWER PLANTS

PAPERS PUBLISHED BY A. S. M. E.

No. 1214. Unnecessary Losses in Firing Fuel Coal: C. R. Weymouth, price $0.30; No. 1213. Fuel Economy Tests at a Large Oil Burning Electric Plant: C. R. Weymouth, price $0.20; No. 1165. The Rational Utilization of Low Grade Fuels in Gas Producers: F. E. Junge, price $0.40; No. 1245. Some Properties of Steam: R. C. H. Heck, price $0.10.

PAPERS ON STEAM ENGINES AND BOILERS

PAPERS PUBLISHED BY A. S. M. E.

No. 1081. Counter Weights for Large Engines: D. S. Jacobus, price $0.20; No. 1329. Strain Measurements of Some Steam Boilers under Hydrostatic Pressure: J. E. Howard, price $0.30; No. 1298. Combustion and Boiler Efficiency: E. A. Uehling, price $0.30; No. 1308. Oil Fuel for Steam Boilers: B. R. T. Collins, price $0.20.

OIL AND GAS ENGINES AND GAS PRODUCERS

POWER PLANT AUXILIARIES AND SPECIALTIES

PAPERS ON POWER PLANT SPECIALTIES

PAPERS PUBLISHED BY A. S. M. E.

No. 1288. Improved Absorption Dynamometer: C. M. Garland, price $0.10; No. 1287. Experimental Analysis of a Friction Clutch Coupling: W. T. Magruder, price $0.20; No. S 43 X. Automatic Control of Condensing Water: B. Viola, price $0.10; No. S 26 X. Air Leakage in Steam Condensers: T. C. McBride, price $0.20.

GREEN ENGINEERING CO.

Steger Building CHICAGO, ILL.

Green Chain Grate Stokers for free burning and coking bituminous coals. GECO Pneumatic Ash Handling Systems.

See pages 50 and 51 of Condensed Catalogues of Mechanical Equipment.

STOKERS
PNEUMATIC ASH CONVEYORS

GREENE, TWEED & CO.

109 Duane St. NEW YORK

Rochester Automatic Force Feed Cylinder Lubricators, for the lubrication of all types of engines, pumps and air and ammonia compressors.

See page 159 of Condensed Catalogs of Mechanical Equipment.

FORCE FEED LUBRICATORS

HOMESTEAD VALVE MANUFACTURING CO.

WORKS: HOMESTEAD, PA. PITTSBURG, PA.

Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most difficult service for water, air or steam. Valves unlike all others.

VALVES

THE HUGHSON STEAM SPECIALTY CO.

CHICAGO, ILL.

Manufacturers of Regulating Valves for all pressures and for steam, air and water. The best and only absolutely noiseless Combination Back Pressure and Relief Valve. Pump Regulators, Separators, Steam Traps, Automatic Stop and Check Valves. Write for complete catalogue.

VALVES
STEAM TRAPS
SEPARATORS
REGULATORS

INGERSOLL-RAND COMPANY

11 BROADWAY NEW YORK

Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

AIR COMPRESSORS
AIR TOOLS AND HOISTS

JENKINS BROS.

NEW YORK BOSTON PHILADELPHIA CHICAGO

Manufacturers of the genuine Jenkins Bros. Valves, made in brass, iron body, and cast steel, in a variety of types, suitable for moderate, medium or extra heavy pressures. Also a line of high grade mechanical rubber goods including sheet packing, gaskets, gasket tubing and pump valves. Illustrated catalogue sent on request.

VALVES
PACKING DISCS

ROBERT A. KEASBEY CO.

100 N. MOORE ST. NEW YORK CITY

Telephone: 6097 Franklin

Heat and Cold Insulating Materials. Headquarters for 85% Magnesia Asbestos and Brine Pipe Coverings, Asbestos Products, etc.

MAGNESIA ASBESTOS AND BRINE PIPE COVERINGS

PAPERS PUBLISHED BY A. S. M. E.

No. 1236. A New Transmission Dynamometer: W. H. Kenerson, price $0.10; No. 1106. A Low-Resistance Thermo-Electric Pyrometer and Compensator: W. H. Bristol, price $0.30; No. 1064. The Bursting of Four-foot Fly-wheels: C. H. Benjamin, price $0.10; No. S 30 Xa. Efficiency Tests of Lubricating Oils: F. H. Sibley, price $0.10.

PAPERS ON POWER PLANT SPECIALTIES

HOISTING AND CONVEYING MACHINERY

AIR COMPRESSORS AND PNEUMATIC TOOLS

ELECTRICAL APPARATUS

PAPERS ON ELECTRICAL APPARATUS

PAPERS PUBLISHED BY A. S. M. E.

No. 472. Electric Power Distribution: H. C. Spaulding, price $0.20; No. 485. The Electric Railway as applied to Steam Roads: B. J. Dashiell, Jr., price $0.10; No. 845. The Mechanical Equipment of the New South Station: W. C. Kerr, price $1.00; No. 1043. Middlesborough Dock Electric and Hydraulic Power Plant: V. L. Raven, price $0.30.

WESTINGHOUSE ELECTRIC & MFG. CO.

PITTSBURGH, PA.

Westinghouse Electric Motor Drive. Pumps, compressors, hoists, machine tools and every class of apparatus develop their highest efficiency when individually driven with Westinghouse Motors.

ELECTRIC MOTOR DRIVE

WESTON ELECTRICAL INSTRUMENT CO.

NEWARK, N. J.

Manufacturers of Miniature Precision Instruments for Direct Current. Over 300 ranges and types for various purposes.

PRECISION INSTRUMENTS

POWER TRANSMISSION

THE AMERICAN PULLEY CO.

PHILADELPHIA, PA.

The American Pulley. The first all steel parting belt pulley made. Now sold in larger quantities than any one make of pulley. No key, no set screw, no slip: light, true and amply strong for double belts. 120 stocks carried in the United States.

PULLEYS

ONEIDA STEEL PULLEY CO.

ONEIDA, N. Y. CHICAGO, ILL.

The largest manufacturers of Pulleys in the world. Our Steel Pulleys range from 6 to 126″ diameter, 3 to 40″ face, and fit any size shaft from 1 to $8\frac{1}{2}$″. Let us send you our booklet illustrating all styles.

PULLEYS

THE A. & F. BROWN CO.

79 Barclay St. NEW YORK

Manufacturers of Shafting, Pulleys, Hangers, etc., for Transmission of Power.

SHAFTING
PULLEYS
HANGERS

DODGE MANUFACTURING CO.

MISHAWAKA, IND.

Manufacturers of everything for the Mechanical Transmission of Power; also Elevating and Conveying Machinery, and the "Eureka" Water Softener. Send for general catalog C-10.

POWER TRANSMISSION
ELEVATORS
CONVEYORS

PAPERS PUBLISHED BY A. S. M. E.

No. 1276. Symposium on Electric Driving in Machine Shop: A. L. DeLeeuw, C. Robbins, J. Riddell and discussion, price $1.10; No. 1335. Variable-speed Power Transmission: G. H. Barrus and C. M. Menly, price $0.10; No. S 47 X. A New Theory of Belt Driving: S. Haar, price $0.20; No. 1239. Transmission of Power by Leather Belting: C. G. Barth, price $0.50.

PAPERS ON POWER TRANSMISSION

POWER TRANSMISSION APPLIANCES

FALLS CLUTCH & MACHINERY CO.

CUYAHOGA FALLS, OHIO

Friction Clutch Pulleys, Couplings, Quills, Operators, Clutch Sheaves, Floor Stands, Heavy Mill Bearings, Shaft Couplings, Sheaves and Tension Carriages, Pulleys and Fly Wheels.

POWER TRANSMISSION

THE HILL CLUTCH COMPANY

CLEVELAND, OHIO

Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

CUT GEARING

SPEED REDUCING TRANSMISSIONS

D. O. JAMES MANUFACTURING CO.

1120-22 W. Monroe St. CHICAGO

Specialists in cut gearing; spur, spiral, bevel, mitre, worms and worm gears, rawhide pinions, racks, incased worm gear reductions, O'K. speed reducing transmissions 4:1 up to 1600:1.

PULLEYS

PAPER FRICTION TRANSMISSION

THE ROCKWOOD MANUFACTURING CO.

INDIANAPOLIS, IND.

Rockwood Paper Frictions have proven their unquestioned superiority. You will find our booklets regarding Transmission of Power by Belts and Friction Transmission desirable additions to your engineering library.

POWER TRANSMISSION

T. B. WOOD'S SONS CO.

CHAMBERSBURG, PA.

Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

ENGINEERING MISCELLANY

ALUMINUM

ALUMINUM COMPANY OF AMERICA

PITTSBURGH, PA.

Aluminum Ingot, Sheet, Rod, Wire, Cable, Tubing and other forms.

PAPERS ON ROLLING MILL MACHINERY

PAPERS PUBLISHED BY A. S. M. E.

No. 868. Some Landmarks in the History of the Rolling Mill: C. H. Morgan, price $0.20; No. 1319. Pressure Recording Indicator for Punching Machinery: C. C. Anthony, price $0.10; No. 1322. Power Forging, with special Reference to Steam Hydraulic Forging Presses: B. Gerdau and G. Mesta, price $0.10.

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

THE AMERICAN SOCIETY
OF MECHANICAL ENGINEERS

THE JOURNAL

VOLUME 35

NEW YORK
PUBLISHED BY THE SOCIETY
29 West 39th Street
1913

INDEX TO THE JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JULY-DECEMBER 1913

INDEX TO THE JOURNAL, JULY-DECEMBER 1913

Note: Items appearing in The Journal as Society Affairs have the month and page number given. Where the list of discussors of a paper is given, the list appears under the straight title of the paper. Papers published in The Journal previous to June, discussion of which was published during July to December, are indicated by the month, followed by 1913.